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OUR COVER

Industrial Quality Control is proud to present a new face this month. Our new cover design—which emphasizes the quality control part of our title and which uses a stylized OC curve as its underlying theme—is the product of many long months of doing and re-doing and of many persons' efforts. We hope you like it.

This month we are pleased to present a view at Ford Motor Company's new Quality Control Center which was just opened up last October. The picture shows a workman checking the body alignment of a '59 Ford for proper door and window openings. See page 18 for a brief description of the Quality Control Center.

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From the President's Desk

Group Insurance—A New Service for Members

For the past year considerable thought and study has been given to the possibility of a new ASQC service consisting of an approved Accident and Sickness Insurance Program available to members and their dependents on a voluntary basis.

The idea was first thoroughly explored by an Insurance Committee of three—Jack E. Davis of Seaman-Andwell Corp., Robert I. Tenney of Fleischman Malting Company, and Howard L. Jones, University of Chicago. It became apparent that the group purchasing power of the membership of the Society made it possible to secure much broader coverage at a substantially lower cost than any member could buy as an individual. The Committee further learned that other societies similar to ours (including ASCE and ASME) have made this style of insurance available to their members. The Committee, therefore, after careful study and examination of several proposed programs, selected the program to be offered and submitted a favorable report to the Executive Committee. After further consideration, the Executive Committee submitted the program to the Board of Directors for final approval which was given at their meeting in Milwaukee on Nov. 15, 1958.

The Group Insurance Program contains three basic Plans:

1. *THE LOSS OF TIME PLAN.* With benefits for loss of time due to accident or sickness and accidental death or dismemberment, for ASQC members only.
2. *THE MAJOR HOSPITAL-NURSE-SURGICAL EXPENSE PLAN.* With benefits for hospital room and board, miscellaneous hospital expenses, nurse expense while in a hospital and after hospital confinement, and surgery. This plan will be offered with the option of either no deductible or $500 deductible coverage. It will be available to members and their spouses and children.
3. *THE SENIOR HOSPITAL-NURSE-SURGICAL PLAN.* With more limited benefits for hospital room and board, miscellaneous hospital expenses, nurse expense while in a hospital, and surgery. This plan is designed primarily for members of the Society over 70 and their spouses.

The following are some of the outstanding advantages of this Group Insurance Program:

1. The insurance of an individual member cannot be cancelled by the company as long as he remains a member of the Society and the Program remains in force. The Loss of Time Plan, of course, must be dropped when a member retires, and the Loss of Time Plan and Major Hospital Plans can be carried up to the premium due date after a member reaches age 70. The Senior Plan will then be available.
2. The Group Insurance Program will be offered to members at rates substantially lower than the cost of the same coverage under individual policies.
3. There will be no physical examination and the application will be an extremely simple one to fill out.
4. Once a certificate of insurance is validly in force, benefits cannot be reduced because of other insurance carried or because an insured performs duties of a more hazardous occupation, if he retains his membership in the Society.
5. The insurance program will provide world-wide coverage.
6. If sickness disability begins after the effective date of a certificate of insurance, coverage is provided, regardless of the date of origin of the ailment. Once a certificate is validly in force, it cannot be changed to eliminate coverage of this ailment.
7. The Major Hospital Plan will be available with the option of a $500 deductible, so as to eliminate duplication of benefits with a basic hospital expense plan a member may already carry.
8. Benefits from the Society's insurance program will be paid regardless of any other insurance which the member may carry.

There will be a Charter Enrollment Period of six months from the date of the first mailing. During that time, if 40 percent of the members enrolled in any section (or of the entire ASQC membership) apply for coverage, all applications received will be accepted regardless of the physical condition of the member (though members over 60 and impaired risks may be limited as to the amount of coverage they can purchase). If, however, less than 40 percent of a local section applies, the company will have the privilege of refusing such applications from that section as it finds necessary due to the physical condition of the member (unless 40 percent of the entire ASQC membership has applied.) (Any section with less than 100 members will be combined with another section for qualification purposes only.)

In the meantime, the insurance company has agreed to make the coverage effective for the insurable members after the first 100 acceptable applications from all sections of the Society have been received, so that there will be no undue delay in coverage for those members who are in good health.

The Program will be administered by Smith, Sternau & Son Corp. of Washington, D.C., and underwritten by the Continental Casualty Company of Chicago.

The key personnel of the Administrator have successfully administered a similar program for the American Society of Civil Engineers over the past ten years, and also administered a program for the American Society of Mechanical Engineers which was started in June of 1958. They assure us that our members will at no time be approached through personal solicitation. Members will soon receive a mailing containing applications and full details of the Program.

The success of the Program will depend upon the interest and active support of our membership. The Board of Directors feels that this is a worthwhile project and it is urged that each member give the matter serious consideration.

E. E. Fisher

How to save 77 years

The boy Galileo sat in the sanctuary of Pisa's great cathedral, observing the movement of a lamp which had been set swinging by a sudden gusty draft. The chain by which it was suspended from the high ceiling was of such a length that the arcs decreased but slowly. Strange thing, though. No matter how far the pendulum swung, its movement consumed the same time. Galileo made a note of that. The year was 1581.

The old man sat at his writing desk, sixty years and a thousand disputes later, writing down a new theory. The regularity of a swinging pendulum might be combined with a spring mechanism to improve the unreliable clocks of that day. So Galileo scribbled on, and did nothing more about it. A number of years after his death Huygens took the notes and invented the pendulum clock. *Seventy-seven years had elapsed since the boy made the observation upon which it was based!*

The creative thinker today still need not have a specific use in mind when, by equation or formula, he branches off from the accepted to the hitherto unknown. The classic invention of this decade, the transistor, evolved in the Bell Telephone Laboratories as scientists sought a deeper understanding of semiconductors. On the other hand, another great invention, the feedback amplifier, came from the acutely creative mind of one Bell engineer faced with a specific problem.

Current Bell Laboratories activities—in such areas as data transmission, radar and submarine cable development—call for the coordinated efforts of all types of thinkers and all types of approaches. One type complements another.

Today, seventy-seven years would not have elapsed between the swinging lamp and the swinging clock pendulum—certainly not at Bell Labs, where ideas, though not rushed, are carefully advanced toward fruitful application in national defense, industry and communications. An important part of this harvest is the efficiency of America's telephone service, unequalled anywhere else in the world.

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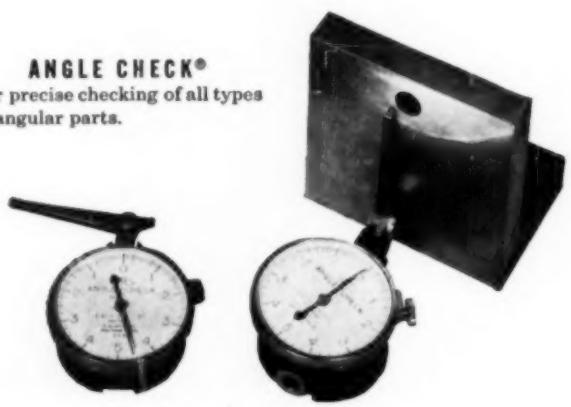


Determination of Optimum Operating Conditions by Experimental Methods

Part II-2, Models and Methods

J. STUART HUNTER

*American Cyanamid Company, New York, N. Y.**

Editorial Note

This is the second installment of Dr. Hunter's part of the major article. The article began in the July 1958 issue of *Industrial Quality Control*. The first installment by Dr. Hunter appeared in the December 1958 issue. Dr. Hunter's third and final installment will appear next month.

Two Dimensional First-Order Designs

Frequently an experimenter may be interested in studying some response variable as a continuous function of two independent controlled variables, i.e.

$$\eta = f(x_1,x_2) \tag{18}$$

As in the one dimensional case (one controlled variable), the first step in exploring this function may be to fit the first-order model

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon \tag{19}$$

to the observations recorded at the different settings of the controlled variables x_1 and x_2. The quantity x_0 in the model always takes the value of unity.

The most popular experimental design for obtaining estimates of the coefficients in this first-order model is the two-level factorial design. This experimental design requires that each controlled variable be fixed throughout the experimental program at a high level and at a low level, and that all possible combinations of high and low levels of the variables be run.

An Example

For example, suppose an experimenter were planning to study the relationship between the expected yield of a chemical process as a function of time and temperature. A two-level factorial design would take the form:

Controlled Variable Levels		Experimental Design Levels	
Time (hours)	*Temp (degrees)*	x_1	x_2
1	240	−1	−1
5	240	1	−1
1	280	−1	1
5	280	1	1

The mathematical model is most conveniently fitted to the experimental design levels rather than to the actual levels of time and temperature. The coding mechanism associating the design variables x_1 and x_2 with time and temperature are

$$x_1 = \frac{\text{Time in hours} - 3}{2}; \quad x_2 = \frac{\text{Temp } ^\circ\text{C} - 260}{20}$$

The four experimental design points, when plotted in the x_1–x_2 coordinate system, form the vertices of a square as illustrated in Fig. 2.

To provide a valid estimate of experimental error suppose that the entire experimental program is repeated and that the responses from the eight randomly run experiments are those given below.

The proposed first-order mathematical model is

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$$

Vector of Obs.	Matrix of Ind. Var.		
y	x_0	x_1	x_2
24	1	−1	−1
24	1	−1	−1
42	1	1	−1
46	1	1	−1
3	1	−1	1
5	1	−1	1
19	1	1	1
21	1	1	1

Coefficients of Normal Equations

				b_0	b_1	b_2	
N	Σx_1	Σx_2	Σy	8	0	0	184
	Σx_1^2	$\Sigma x_1 x_2$	$\Sigma x_1 y$		8	0	72
		Σx_2^2	$\Sigma x_2 y$			8	−88

The fitted first-order equation is therefore

$$\hat{y} = 23 + 9x_1 - 11x_2$$

Analysis of Variance Table

	ss	*df*	*ms*	*F*
Σy^2	5864	8		
Due to b_0	4232	1		
Due to b_1	648	1	648	$F_{1,4}$***
Due to b_2	968	1	968	$F_{1,4}$***
Residual $\Sigma(y-\hat{y})^2$	16	5		
Lack of Fit	4	1	4	$F_{1,4} = \frac{4}{3} = 1.33$†
Error $= \Sigma d^2/2$	12	4	$s^2 = 3$	

***Very significant. †Non-significant.

A valid estimate of the experimental error variance $s^2 = 3$ based on four degrees of freedom is obtained from the pairs of observations at each of the four settings of x_1 and x_2. In the analysis of variance the lack of fit test is found to be non-significant, and the hypothesis that $\beta_1 = 0$ or $\beta_2 = 0$ is rejected. The viewpoint is therefore taken that the fitted model adequately represents the data. (See Fig. 3.)

*Presently with the Statistical Techniques Research Group, Princeton University.

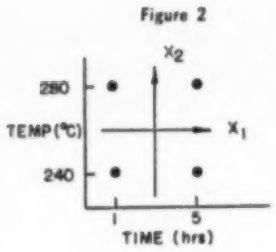
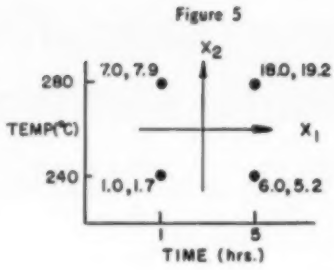


Figure 2



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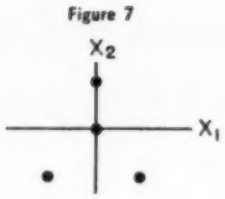

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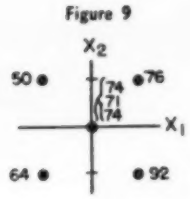

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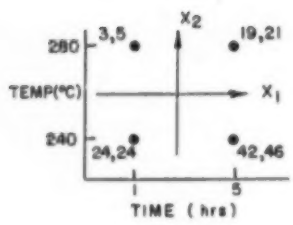

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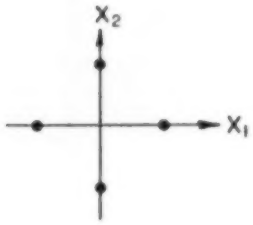

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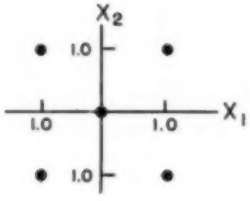

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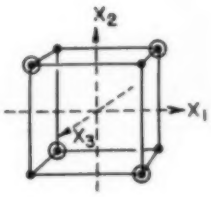

Figure 10

It is of considerable interest now to see how this fitted model can be used to "map" empirically the response function over the experimental region. Substituting the quantity $\hat{y} = 20$ in the fitted model gives $9x_1 - 11x_2 + 3 = 0$, the equation of a straight line in the coordinate system of x_1 and x_2. Everywhere along this line the response is predicted equal to 20 and the line can therefore be viewed as a contour. Plots for $\hat{y} = 10$, 20, 30 and 40 are given in Fig. 4. A geographer viewing such a collection of contours would immediately know the surface under study was planar, the contours being straight lines equally spaced. In similar fashion, the unknown response function over the region studied can be viewed as a planar response surface. This "picture" of the form of the response function over the region studied provides the experimenter with a convenient sense of the nature of the response function. An application of these contour maps will be described later in the section on steepest ascent. It should be noted that the map of the fitted response function is extended only very slightly beyond the experimental design points since extrapolation beyond this region could be subject to considerable error.

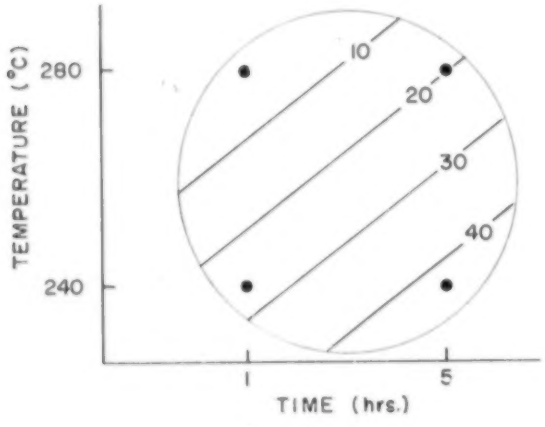

Figure 4

An Illustration With Lack of Fit

The example just given is one in which the first-order model was found to represent adequately the unknown response function. Let us now repeat the example with another set of observations given below, for which the model will no longer be adequate to represent the response.

The proposed first-order model is

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2$$

Vector of Obs.	Matrix of Ind. Var.			Coefficients of Normal Equations						
y	x_0	x_1	x_2	b_0	b_1	b_2		b_0	b_1	b_2	
1.0	1	−1	−1	N	Σx_1	Σx_2	Σy	8	0	0	66.0
1.7	1	−1	−1		Σx_1^2	$\Sigma x_1 x_2$	$\Sigma x_1 y$		8	0	30.8
6.0	1	1	−1			Σx_2^2	$\Sigma x_2 y$			8	38.2
5.2	1	1	−1								
7.0	1	−1	1								
7.9	1	−1	1								
18.0	1	1	1								
19.2	1	1	1								

The fitted equation is (see Fig. 5)

$$\hat{y} = 2.25 + 3.85x_1 + 4.78x_2$$

Analysis of Variance Table

	ss	*df*	*ms*	*F*
Σy^2	870.980	8		
Due to b_0	544.500	1		
Due to b_1	118.500	1	118.5	
Due to b_2	182.405	1	182.4	
Residual $\Sigma(y-\hat{y})^2$	25.575	5		
Lack of Fit	23.885	1	23.885	$F_{1,4} = 56.5^{**}$
Errors $= \frac{\Sigma d^2}{2}$	1.690	4	0.422	

**Significant at the 1% level.

As before, a valid estimate of the experimental error variance is obtained from the repeated trials at each of the four settings of x_1 and x_2. We note immediately that the lack of fit term in the analysis of variance table

is highly significant. This informs us that the variability about the fitted function is very much greater than that which can be expected from error alone. The postulated model must now be discarded and other models tried.

The question now arises, what sort of terms should be added to the model so that it can more adequately represent the data? If a new variable is added to the model composed of the product of x_1 and x_2, that is the term x_1x_2, the following new mathematical model can be constructed:

$$y = \beta_0x_0 + \beta_1x_1 + \beta_2x_2 + \beta_{12}x_1x_2 + \varepsilon \quad (20)$$

The term x_1x_2 is often called the "interaction" between the independent controlled variables x_1 and x_2. In the example, the coefficient β_{12} can be estimated from the data. However, this "interaction" mathematical model is an "incomplete-order" model; the terms forming this model include all possible first-order effects, β_1 and β_2, but only one of the three possible second-order effects, that is only β_{12}. It is important to remember, as in the case of one controlled variable, that it is the *order* of approximation to the data that counts, not the individual terms making up the order of approximation. A full second-order model in two dimensions is

$$y = \beta_0x_0 + \beta_1x_1 + \beta_2x_2 + \beta_{11}x_1^2 + \beta_{22}x_2^2 + \beta_{12}x_1x_2 + \varepsilon \quad (21)$$

To determine a second-order approximation to the data, it is necessary to find the coefficient estimates b_{11} and b_{22} as well as b_{12}. It can be quickly shown that it is impossible to obtain estimates of either b_{11} or b_{22} from a two-level factorial design. Writing down the matrix of independent variables associated with the second-order model derived from a 2^2 factorial design gives

x_0	x_1	x_2	x_1^2	x_2^2	x_1x_2
1	−1	−1	1	1	1
1	1	−1	1	1	−1
1	−1	1	1	1	−1
1	1	1	1	1	1

We observe now that there is no way of distinguishing the column vectors associated with the independent variables x_0, x_1^2, and x_2^2. They are identical. When this occurs, the estimates of the associated coefficients are said to be perfectly "confounded."

It is always of interest to identify the source of a lack of fit sum of squares. In this example, which uses a 2^2 factorial design the x_1x_2 interaction will completely explain away the lack of fit sum of squares. This evidence of a significantly large interaction sum of squares is sufficient to destroy the utility of the first-order model. It is not always sufficient however merely to add the interaction term to the original model and conclude that the resultant fitted equation adequately represents the observed data. The fitted equations may estimate the observed responses very closely indeed and hence be adequate for some purposes. However, a thorough comprehension of the role that the independent variables x_1 and x_2 play in affecting the response y in this example requires a *full* second-order model; i.e., the first-order terms and both the quadratic and interaction second-order terms. It should also be noted that our present ability to measure the crossproduct (interaction) coefficient is a function solely of the experimental design. For example, if the 2^2 factorial design shown in Figure 2 is merely rotated 90° we obtain the design shown in Fig. 6. This is a perfectly good first-order design, and is the 2^2 factorial except for orientation. The design does not however provide any information whatever on the crossproduct (interaction) term. Since the orientation of the response surface relative to the axes of the experimental design is almost always unknown, the use of incomplete-order models can give a very misleading interpretation of the unknown response function. There will be more said about this subject later.

The Equilateral Triangle Design

Another first-order experimental design in two dimensions is the "Equilateral Triangle" design. As its name implies, the design coordinates form the vertices of an equilateral triangle in the x_1–x_2 coordinate system. To provide a measure of experimental error and a measure of lack of fit, i.e. non-first orderness, two or more additional experimental points can be added to the center of the design. The following example illustrates the use of an equilateral triangle design. (See Fig. 7.)

Vector of Obs. y

$$\begin{bmatrix} 2 \\ 14 \\ 20 \\ 15 \\ 17 \end{bmatrix}$$

Matrix of Ind. Var.

x_0	x_1	x_2
1	$-\sqrt{6}/2$	$-\sqrt{2}/2$
1	$\sqrt{6}/2$	$-\sqrt{2}/2$
1	0	$\sqrt{2}$
1	0	0
1	0	0

Coefficients

5	0	0	68
	3	0	$6\sqrt{6}$
		3	$12\sqrt{2}$
5	0	0	68
1	0	0	13.6
	3	0	$6\sqrt{6}$
	1	0	$2\sqrt{6}$
		3	$12\sqrt{2}$
		1	$4\sqrt{2}$

The fitted equation is

$$\hat{y} = 13.6 + 2\sqrt{6}x_1 + 4\sqrt{2}x_2$$

Regression Analysis Table

	ss	*df*	*ms*	
Σy^2	1114.0	5		
Due to b_0	924.8	1		
Due to b_1	72.0	1		
Due to b_2	96.0	1		
Residual	21.2	2		
Lack of Fit	19.2	1	19.2	$F_{1,1} = 9.6$†
Experimental Error = $(2)^2/2$	2.0	1	2.0	

†Non-significant

The sum of squares for experimental error is determined from the pair of observations taken at the center of the design. We observe that the lack of fit term is not significant and may conclude that the fitted first-order model is an adequate representation of the responses.

The cause of the lack of fit sum of squares, in this example, can be appreciated intuitively by first imagining the response y to be really planar in nature. If this is so, then the average of the observations taken at the vertices of the design should equal the average of the observations taken at the center of the design. The sum of squares for the lack of fit term is a measure of the difference between these two averages.

The 2^2 Factorial With Center Points

An interesting first-order experimental design is provided by the 2^2 factorial design with replicated center points as illustrated in Fig. 8.

A measure of the experimental error is provided by the repeated center points, although the entire design could be replicated and the differences in the response observed at each experimental point used to provide an estimate of σ^2.

Two measures of lack of fit of a first-order model are made available by this design. One degree of freedom for this lack of fit is provided by the "interaction" term, b_{12}, which can be estimated. A second degree of freedom is provided by the contrast of the average value of the peripheral observations against the average of the observations at the center of the design. The sum of squares associated with this contrast measures the sum of squares of the effects of the purely quadratic terms, that is of b_{11} plus b_{22}. A worked example using this design is given below. (See Fig. 9.)

The first-order model is

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$$

Vector of Obs.	Matrix of Ind. Var.	
y	x_1	x_2
64	−1	−1
92	1	−1
50	−1	1
76	1	1
74	0	0
71	0	0
74	0	0

Coefficients of Normal Equations

N	Σx_1	Σx_2	Σy	7	0	0	501
	Σx_1^2	$\Sigma x_1 x_2$	$\Sigma x_1 y$		4	0	54
		Σx_2^2	$\Sigma x_2 y$			4	−30
				7	0	0	501
				1	0	0	71.57143
					4	0	54
					1	0	13.50
						4	−30
						1	− 7.50

The solution for the coefficients is

$$(1)b_2 = -7.50$$
$$(1)b_1 + (0)b_2 = 13.50$$
$$(1)b_0 + (0)b_1 + (0)b_2 = 71.57$$

and the fitted model is

$$\hat{y} = 71.57 + 13.50x_1 - 7.50x_2$$

Regression Analysis Table

	ss	*df*	*ms*	
Σy^2	36829	7		
Due to b_0	35857.29	1		
Due to b_1	729.00	1	729.00	**
Due to b_2	225.00	1	225.00	**
Residual	17.71	4	4.61	
Lack of Fit	11.71	2	6.21	†
Error	6.00	2	3.00	

$$\text{Error Sum of Squares} = 74^2 + 71^2 + 74^2 - \frac{(74 + 71 + 74)^2}{3}$$
$$= 15993 - 15987 = 6.0$$

**Significant at the 1% level. †Non-significant.

Proceedings of the Second Annual Conference Administrative Applications Division

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The lack of fit sum of squares is found to be non-significant, i.e. $F_{2,2} = 6.21/3.00 = 2.07$. The sum of squares associated with the two degrees of freedom for lack of fit can be separated, with this given design, into two orthogonal components: the crossproduct or interaction sum of squares and a sum of quadratic effects sum of squares.

The Lack of Fit Test

The initial test of the adequacy of the fitted model is provided by the "lack of fit" F ratio obtained by dividing the lack of fit mean square by the error mean square. The error mean square is an estimate of σ^2 independent of any model since it is obtained from repeated observations only. When the variations of the observations about a fitted model approximate those which occur from errors of observation alone, then the lack of fit mean square also becomes a measure of the error variance σ^2. The F ratio determines the probability that both mean squares are estimates of the *same* error variance. When the F ratio is found to be non-significant, the experimental evidence does not contradict the assumption that both mean squares are computed from error distributions with the same variance and hence it is concluded that the fitted model can adequately represent the data since the variation about the fitted model is not unlike the errors natural to the experimental environment. A significant F ratio is testimony that the variability about the fitted model is larger than that which can be expected from errors of observation alone and hence that the model fails adequately to represent the data.

It must be remembered, however, that the lack of fit F test may be non-significant and the fitted model be of little or no value whatever. Thus the elements comprising the model must also be tested to determine whether or not they explain away variability in the data that is significantly larger than that due to error alone. Finally, the ability of the F test to detect lack of fit, when it exists, depends in large part on the number of degrees of freedom both in the estimate of the error variance and in the lack of fit mean square. The degrees of freedom for error are obtained through replication, and good practice requires an absolute minimum of four or five degrees of freedom (or an estimate from previous work.) Degrees of freedom for lack of fit are acquired by ensuring that the experimental design contains several more geometric points than the minimum number necessary for estimating the coefficients in the model.

Orthogonal Estimates

In the examples above the sums of squares associated with the coefficients b_1 and b_2 have not been recorded with the qualifying assertion, "$b_1|b_0$" and "$b_2|b_1, b_0$;" that is, "b_1 given that b_0 has been determined;" and "b_2 given that b_1 and b_0 have been determined."

The independence of the sum of squares associated with these estimated coefficients is the direct result of designing the experiments. The array of points in the x_1–x_2 coordinate system were carefully chosen so that $\Sigma x_1 = 0$, $\Sigma x_2 = 0$ and $\Sigma x_1 x_2 = 0$. These provided a set of coefficients in the normal equations in which all the off diagonal elements were zero, and hence, the solution for any one of the unknown coefficients could be made directly without any reference to any other estimate. When this phenomenon occurs we state that the estimated coefficients are "orthogonal" one to another. Said another way, the sign and magnitude of each predicted coefficient in no manner depends on either the sign or

magnitude of any other coefficient. When the estimates are orthogonal, the sums of squares associated with these estimates are similarly orthogonal and their order of appearance in the Analysis of Variance Table is of no consequence.

An Example of Non-orthogonal Estimates

As an example of non-orthogonal estimation, a first-order model has been fitted to the following data; we are given the following vector of observations and associated settings of temperature and catalyst/nitrile ratio.

Response	Controlled Variables		Coded Controlled Variables	
y	*Temp*	*C/N ratio*	x_1	x_2
23	110	0.54	−0.55	−1.075
27	117	0.63	0.85	0.725
24	113	0.71	0.05	2.325
22	107	0.48	−1.15	−2.275
32	118	0.57	1.05	−0.475
29	117	0.63	0.85	0.725
18	102	0.59	−2.15	−0.075
31	118	0.60	1.05	0.125

The levels of the controlled variable are coded so as to minimize rounding errors in the solution of the normal equations. Ideally a coding mechanism should be used which would guarantee that $\Sigma x_1 = 0$ and that $\Sigma x_1^2 = N$, for example letting $x_1 = (\text{Temp} - 112.75)/\sqrt{30.9375}$. However, forcing $\Sigma x_1 = 0$ and $\Sigma x_1^2 = N$ can also cause considerable rounding difficulties and certain compromises are usually required, particularly if desk computers are to be used. In this problem the coding mechanisms used were

$$x_1 = \frac{(\text{Temp} - 112.75)}{5.00} \text{ and } x_2 = \frac{(\text{C/N} - 0.59375)}{0.05}$$

which resulted in $\Sigma x_1 = 0$, and Σx_1^2 and Σx_2^2 both approximately equal to N. Forcing the $\Sigma x_1 = 0$ is of greater importance whenever second- or higher-order models are considered.

Determining the coefficients in the first-order model $y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$, the Forward Doolittle Table is constructed. We note before starting that $\Sigma x_1 x_2 \neq 0$. Whenever this occurs the estimates b_1 and b_2 associated with x_1 and x_2 are termed "non-orthogonal".

N	Σx_1	Σx_2	Σy
	Σx_1^2	$\Sigma x_1 x_2$	$\Sigma x_1 y$
		Σx_2^2	$\Sigma x_2 y$

8	0	0	206
	9.9000	4.3500	38.30
		13.0350	8.950
8	0	0	206
1	0	0	25.750000
	9.900000	4.350000	38.300000
	1	0.439394	3.868687
		11.123636	−7.878790
		1	−0.708293

$$b_2 = -0.708293$$

$$(1)b_1 + (0.439394)b_2 = 3.868687$$

$$(1)b_0 + (0)b_1 + (0)b_2 = 25.75$$

$$b_0 = 25.75$$

$$b_1 = 4.17991$$

The fitted model is

$$\hat{y} = 25.75 + 4.18x_1 - 0.71x_2$$

Regression Analysis Table

	ss	*df*	*ms*	
Σy^2	5468.0000	8		
b_1	5304.5000	1		
b_1	148.1707	1	148.1707	$F_{1,5} = 75.99$**
$b_2 \mid b_1$	5.5805	1	5.5805	$F_{1,5} = 2.86$†
Residual	9.7488	5	1.9498	

**Significant at the 1% level. †Non-significant.

We observe first that the estimate of variance, based on five degrees of freedom, is $s^2 = 1.9498$; thus $s = 1.40$. If, based upon our knowledge of the environment surrounding this experiment, this estimate appears to be reasonable, then we would declare that temperature (x_1) had an important affect on the response and that the catalyst to nitrile ratio (x_2), after taking into account the effect of temperature, was of no significance.

Suppose, however, that we had reversed the positions of x_1 and x_2 in the first-order model; that is, let $y = \beta_0 x_0 + \beta_2 x_2 + \beta_1 x_1 + \varepsilon$. The Forward Doolittle and regression analysis table then become

Forward Doolittle

8	0	0	206
	13.0350	4.3500	8.9500
		9.9000	38.3000
8	0	0	206
1	0	0	25.75
	13.0350	4.350000	8.950000
	1	0.333717	0.686613
		8.448331	35.313233
		1	4.179906

Regression Analysis Table

	ss	*df*	
Σy^2	5468.0000	8	
b_0	5304.5000	1	
b_2	6.1452	1	†
$b_1 \mid b_2$	147.6060	1	**
Residual	9.7488	5	1.9498

**Significant at the 1% level.
†Non-significant.

Solving of the b's gives $\hat{y} = 25.75 - 0.71x_2 + 4.18x_1$, the same prediction equation as before.

We note however, that the sums of squares in the regression analysis table are different, although the residual sum of squares remains unchanged. Whenever two or more estimates are non-orthogonal the overall sum of squares absorbed by the total regression will remain fixed. However, the sums of squares attached to the individual coefficients will change depending on the position of the variables in the Forward Doolittle Solution. We note that the sum of squares for b_2 equals 6.1452 in the second table, but that $b_2 \mid b_1$ (b_2 given b_1 has already been estimated) in the first table equals 5.5805. In neither case was b_2 significant and it is now possible to conclude that x_2 has no effect on the response, regardless of the role of x_1. The variable x_1 continues to have a significant effect upon the response even after being adjusted for x_2.

First-Order Experimental Designs: Three or More Controlled Variables

Situations in which a response η may be a function of three or more variables are not at all uncommon. In many chemical processes, for example, the yield of the process may be a function of the time of reaction, temperature, ratios of the reactants, pH, pressure, etc. For the moment, suppose the response η is a function of three controlled variables, i.e.

$$\eta = f(x_1, x_2, x_3) \qquad (22)$$

The first-order model in three dimensions is

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon \qquad (23)$$

As in the case of two dimensions, the two-level factorial design in three dimensions provides all the informa-

tion necessary to estimate all the coefficients in a first-order model. Measures of the lack of fit of the model are provided by the capacity of the design to permit the estimation of the interaction terms from the associated second-order model. The 2^3 factorial design alone does not provide an estimate of the experimental error and must be replicated, at least in part, to provide an estimate of σ^2. An additional measure of lack of fit of the first-order model can be obtained from observations taken at the center of the design array.

However, the two-level factorial design requires $2^3 = 8$ experimental points not counting extra trials run at the center of the design array. A certain half-fraction, called a "half-replicate", of the 2^3 factorial contains four points and is in itself a first-order design in three dimensions since it too provides orthogonal minimum variance estimates of the coefficients in the mathematical model. The design coordinates for the 2^3 factorial and the two half-replicates of the 2^3 factorial are given below.

2^3 Design			The two half-replicates of the 2^3 Factorial					
x_1	x_2	x_3	x_1	x_2	x_3	x_1	x_2	x_3
−1	−1	−1	−1	−1	−1	−1	−1	1
1	−1	−1	1	1	−1	1	−1	−1
−1	1	−1	1	−1	1	−1	1	−1
1	1	−1	−1	1	1	1	1	1
−1	−1	1						
1	−1	1						
−1	1	1						
1	1	1						

The coordinates of the points comprising a 2^3 factorial design form the vertices of a cube as illustrated in Fig. 10. The coordinates of the points comprising the half-replicate of the 2^3 factorial design form the vertices of a tetrahedron. These points are circled in Fig. 10. The remaining four points also form the vertices of a tetrahedron and compose the second half-replicate.

One consequence of using either half-replicate alone is that no measure of the possible lack of fit of the first-order model

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon$$

is provided (unless the precaution is taken of running center points). Furthermore, if an $x_i x_j$ interaction term really exists, it will bias the estimate of the x_k main effect, i.e. if β_{12} exists it will bias the estimation of β_3. If both half-replicates are run in sequence, the resulting data will provide independent estimates of b_0, b_1, b_2, and b_3 and measures of lack of fit of the first-order model, since it will now also be possible to secure independent estimates of the interaction coefficients b_{12}, b_{13}, and b_{23}.

For $k = 4$ controlled variables the sixteen points of a 2^4 factorial design, or either of the two half-replicates of the 2^4 factorial design given below, will permit the estimation of all the coefficients in the first-order model

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \varepsilon \quad (24)$$

unbiased by any possible interaction coefficient β_{ij}. The eight points comprising these designs are excellent first-order designs since they provide degrees of freedom for lack of fit (with or without center points).

x_1	x_2	x_3	x_4	x_1	x_2	x_3	x_4
−1	−1	−1	−1	1	−1	−1	−1
1	1	−1	−1	−1	1	−1	−1
1	−1	1	−1	−1	−1	1	−1
−1	1	1	−1	1	1	1	−1
1	−1	−1	1	−1	−1	−1	1
−1	1	−1	1	1	1	−1	1
−1	−1	1	1	1	−1	1	1
1	1	1	1	−1	1	1	1
0	0	0	0	0	0	0	0
.	.	.	. *	.	.	.	. *
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
0	0	0	0	0	0	0	0

*Possible replicated center points.

For $k = 5$ controlled variables the two half-replicates of the 2^5 factorial designs containing 16 points (with or without center points) will each provide estimates of all the coefficients in the first-order model

$$y = \beta_0 x_0 + \sum_{i=1}^{5} \beta_i x_i + \varepsilon$$

Measures of the lack of fit of the first-order model are provided since each half-replicate will also provide independent estimates of all the ten crossproduct coefficients b_{ij}. These two half-replicates of the 2^5 factorial are listed below.

x_1	x_2	x_3	x_4	x_5	x_1	x_2	x_3	x_4	x_5
−1	−1	−1	−1	−1	−1	−1	−1	−1	1
1	1	−1	−1	−1	1	1	−1	−1	1
1	−1	1	−1	−1	1	−1	1	−1	1
−1	1	1	−1	−1	−1	1	1	−1	1
1	−1	−1	1	−1	1	−1	−1	1	1
−1	1	−1	1	−1	−1	1	−1	1	1
−1	−1	1	1	−1	−1	−1	1	1	1
1	1	1	1	−1	1	1	1	1	1
1	−1	−1	−1	1	1	−1	−1	−1	−1
−1	1	−1	−1	1	−1	1	−1	−1	−1
−1	−1	1	−1	1	−1	−1	1	−1	−1
1	1	1	−1	1	1	1	1	−1	−1
−1	−1	−1	1	1	−1	−1	−1	1	−1
1	1	−1	1	1	1	1	−1	1	−1
1	−1	1	1	1	1	−1	1	1	−1
−1	1	1	1	1	−1	1	1	1	−1

Fractional factorial designs are available, however many controlled variables are under investigation.

An Alternative Calculation Format

Because of the unique nature of the two-level factorial designs alternative calculation techniques can be proposed that are quicker to use than the formal construction and solution of the normal equations as given above. For example, so long as the experimental design is a 2^k factorial or fractional factorial, with or without center points, the estimates of the coefficients in a first-order model are given by

$$b_0 = \frac{(0y)}{N};\ b_1 = \frac{(1y)}{n_c};\ b_2 = \frac{(2y)}{n_c};\ \ldots;$$

$$b_k = \frac{(ky)}{n_c}, \quad (25)$$

where N is the total number of observations, and n_c the total number of design points having coordinates

(±1, ±1, ..., ±1), and where (0y), (1y), (2y), ..., (ky) are the scalar product of the observations y_i with the corresponding elements of x_0, x_1, x_2, ..., x_k in the matrix of independent variables. For example, suppose a half-replicate of a 2^4 factorial with four center points had given the following data.

The proposed first-order model is

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \varepsilon$$

Vector of Obs.	Matrix of Ind. Var.				
y	x_0	x_1	x_2	x_3	x_4
10	1	−1	−1	−1	−1
21	1	1	1	−1	−1
26	1	1	−1	1	−1
31	1	−1	1	1	−1
21	1	1	−1	−1	1
25	1	−1	1	−1	1
30	1	−1	−1	1	1
39	1	1	1	1	1
22	1	0	0	0	0
24	1	0	0	0	0
26	1	0	0	0	0
25	1	0	0	0	0

Then

N = total number of points = 12

n_c = total number of (±1, ±1, ±1, ±1) points = 8

$$(0y) = 1(10) + 1(21) + 1(26) + \ldots + 1(25) = \Sigma y = 300$$

$$(1y) = -1(10) + 1(21) + 1(16) - \ldots + 0(25) = \Sigma x_1 y = 11$$

$$(2y) = -1(10) + 1(21) - 1(26) + \ldots + 0(25) = \Sigma x_2 y = 29$$

$$(3y) = -1(10) - 1(21) + 1(26) + \ldots + 0(25) = \Sigma x_3 y = 49$$

$$(4y) = -1(10) - 1(21) - 1(26) - \ldots + 0(25) = \Sigma x_4 y = 27$$

The estimated coefficients are

$$b_0 = \frac{300}{12} = 25;\ b_1 = \frac{11}{8} = 1.4;\ b_2 = \frac{29}{8} = 3.6;$$

$$b_3 = \frac{49}{8} = 6.1;\ b_4 = \frac{27}{8} = 3.4$$ giving the fitted model

$$\hat{y} = 25 + 1.4x_1 + 3.6x_2 + 6.1x_3 + 3.4x_4$$

The general analysis of variance table for a first-order model, given that a 2^k factorial or fractional factorial has been used, with or without center points, is given by

Sum of Squares			df	
Crude Sum of Squares	$\Sigma y^2 = S$		N	
Sum of Squares for b_0	$(0y)^2/N = S_0$		1	
Sum of Squares for b_1	$(1y)^2/n_c$	$S_{1.0}$	1	k
Sum of Squares for b_2	$(2y)^2/n_c$		1	
	. .		.	
	. .		.	
	. .		.	
Sum of Squares for b_k	$(ky)^2/n_c$		1	
Residual	$\Sigma(y-\hat{y})^2 = S-S_0-S_{1.0} = S_R$		$N-(k+1)$	
Lack of Fit Sum of Squares	S_R-S_e		$N-(k+1)-v$	
Error Sum of Squares	S_e		v	

where v is the number of degrees of freedom entering the independent estimate of variance. The analysis of variance for the example above is then:

	ss	df	ms	
Σy^2	8026	12		
Due to $b_0 = (0y)^2/N$	7500	1		
Due to $b_1 = (1y)^2/n_c$	15.125	1		
Due to $b_2 = (2y)^2/n_c$	105.125	1		
Due to $b_3 = (3y)^2/n_c$	300.125	1		
Due to $b_4 = (4y)^2/n_c$	91.125	1		
Residual Sum of Squares	13.500	7		
Lack of Fit Sum of Squares	4.750	4	1.2	$F_{4,3}$†
Error Sum of Squares	8.750	3	2.9	

†Non-significant

(The error sum of squares is computed from the replicated points at the center of the design, i.e. at the point [0, 0, 0, 0].) It would appear in this example that all the estimated coefficients are significantly different from zero.

Applications of First-Order Models

Estimating a Planar Response

The theoretical physicist attempts to portray nature with the most elemental mathematical form possible. The first-order mathematical model illustrated by the general equation

$$y = \beta_0 x_0 + \sum_{i=1}^{k} \beta_i x_i + \varepsilon \qquad (26)$$

is certainly the simplest of these forms. It states that the effect of, say, variable x_2 upon the response y is additive and quite independent of the roles of x_1, x_3, ... x_k. We note that the familiar formulas from physics:

$$E = IR;\ P = \frac{MRT}{V}$$

when written in logarithmic form yield a first-order model.

There are of course many experimental situations where a first-order mathematical model—a straight line where there is one controlled variable, a plane where there are two controlled variables, and a hyperplane for more than two controlled variables—provides a meaningful representation of a response function. In these situations the coefficients in the first-order model are best estimated using data obtained from the settings of the controlled variables determined by the coordinates of a first-order, 2^k factorial, or fractional factorial design with, perhaps, points added at the center of the design. An illustration of the estimation of the coefficients in a first-order model using a 2^2 factorial design was given earlier.

Estimating a Path of Steepest Ascent

Frequently the question is asked, "What combination of levels of the controlled variables will give the highest response?" In attempting to answer this question several alternative experimental approaches are possible. The experimenter may randomly select different settings of the controlled variables, try them in his laboratory or pilot plant, and with luck gravitate to the maximum point. Or he may run a sequence of experiments over a grid covering the entire region of interest and thus literally map the response. Both these approaches can require a great many experimental runs and are usually avoided.

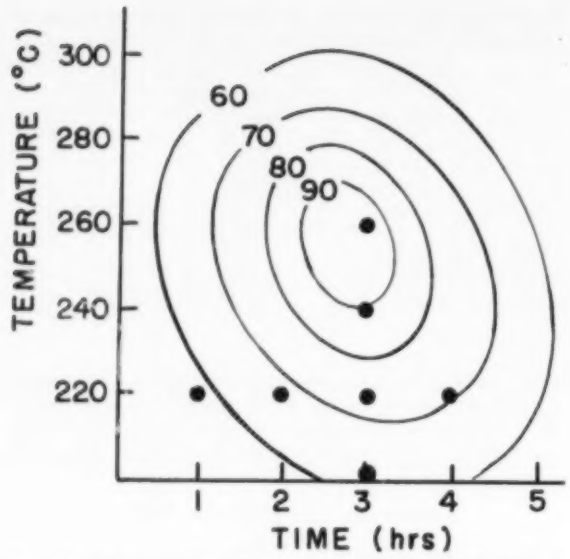

Figure 11—Contours of Equal Response for y = Percent of Theoretical Yield (Illustration of Method of One Factor at a Time)

A favorite and classical attack is the method of one factor at a time. This method requires that the experimenter hold all the controlled variables save one at some constant level, and vary the remaining single variable until a maximum response is observed. Then, holding this variable at its optimum value, a second variable is varied, and so on. The method is illustrated below for the case of $k = 2$ controlled variables.

Suppose a response y (percent of theoretical yield) is a function of time (measured along the x_1 axis), and temperature (measured along the x_2 axis). Suppose further that the response, when viewed geometrically, has the appearance of a mound with a single maximum point. This response is illustrated by means of the contour diagram in Fig. 11.

Using the method of one factor at a time, the experimenter might hold the temperature constant at 220 degrees and vary the time in one hour increments. The resultant experimental trials are shown by the horizontal line of heavy dots in Fig. 11. Deciding that three hours was the best time, he would then hold the time constant at this value and vary the temperature in, say, increments of 20 degrees. This gives the series of experiments illustrated by the vertical line of dots. Thus the procedure leads the experimenter to the point of maximum response.

However, suppose that instead of a mound (which clearly leads to a single maximum point), the response were slightly more complicated and had the appearance of a rising ridge as shown in Fig. 12. The identical procedure illustrated by the dots in Fig. 12 leaves the experimenter with the conviction that the setting of three hours and 220 degrees is optimum, for steps higher or lower in either time or temperature from this point will produce a decrease in the response. Obviously, from the "map," higher yields are possible. But in this instance the experimenter is stuck on a ridge and can only discover the higher yields by varying time and temperature simultaneously and in the proper amounts so that he proceeds in the proper direction.

A method which guarantees that the experimenter will tend toward the maximum point regardless of the form of the response surface (save that it is continuous) is the method of steepest ascents as described in the paper "On the Experimental Attainment of Optimum Conditions" by G. E. P. Box and K. B. Wilson in the *Journal of the Royal Statistical Society, Series B*, in 1951.[1] This technique makes use of the first-order mathematical model, and a first-order experimental design, that is either the two-level factorial or the fractional factorial design. An important concept behind the idea of predicting a path of steepest ascent is simply that a plane does a good job of approximating a curved surface within a limited area. This is analogous to the old argument that straight lines do a good job of approximating curved lines over small intervals. The plan then is to predict the best fitting plane in some small sub-space of the experimental region. Noting the tilt of the fitted plane, a path of steepest ascent can be predicted. Experiments are then performed along this path until a decline in response is noted. Additional observations taken in and around this point can confirm whether a maximum has been reached, whether a new path of steepest ascent can be predicted, or whether the response surface should be mapped in this important region.

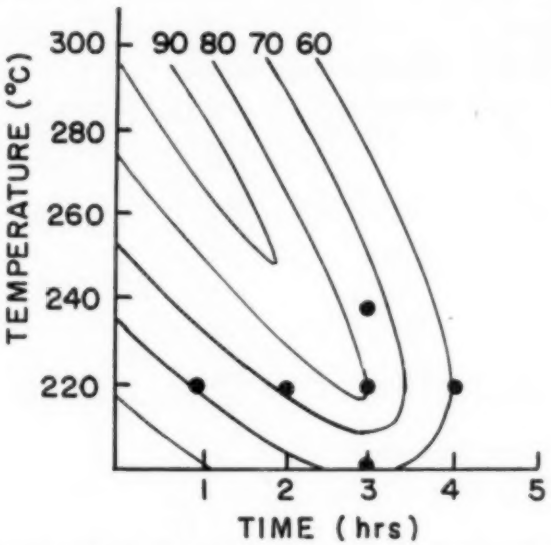

Figure 12—Contours of Equal Response for y = Percent of Theoretical Yield (Illustration of Method of One Factor at a Time)

For example, imagine that a two-level factorial design had been run in the region illustrated by the small circles in Fig. 13. The following table of results would be observed.

Controlled Var. Levels		Exper. Design Levels		Response
Time (hours)	*Temp (degrees)*	x_1	x_2	y
0.5	210	−1	−1	51%
1.0	210	1	−1	57%
0.5	220	−1	1	55%
1.0	220	1	1	61%

Fitting the first-order model one obtains for the best fitting plane in this region.

$$\hat{y} = 56 + 3x_1 + 2x_2$$

The path of steepest ascent is now determined by the coefficients of x_1 and x_2. In this example we are advised that for every three units x_1 is changed, x_2 should be simultaneously changed two units. The

changes requested are proportional to the size and signs of the coefficients in the first-order model. The units that are considered here are the units of the design variables, not the levels of the controlled variables. The path of steepest ascent can also be determined by actually plotting the contours predicted by the fitted model and then moving perpendicularly to these contour lines. The predicted path of steepest ascent is shown in the figure. Experiments along this path lead to the crest of the ridge. A second attempt to fit a first-order model (to re-orient the path of steepest ascent) would likely prove unsuccessful in this instance since the curvature of the unknown response in this new region would provide a significant lack of fit term in the analysis. A second-order model would then be postulated, and the experimental designs and methods of analysis described in later sections used to determine the shape and orientation of the ridge, so that further improvement in response could be obtained. Should the response be a simple mound as in Fig. 11, the first predicted path should lead the experimenter close to the maximum point.

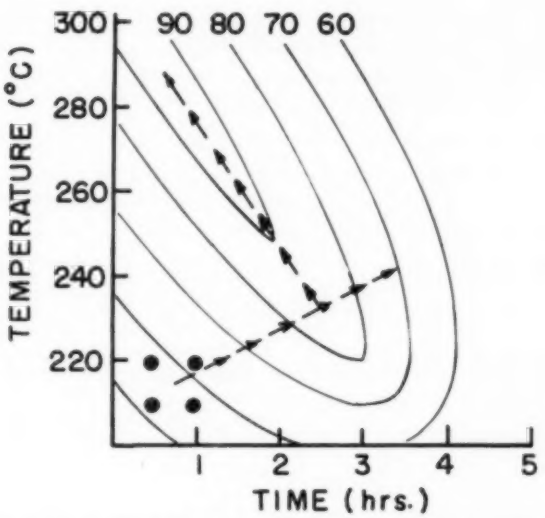

Figure 13—Contours of Equal Response for y = Percent of Theoretical Yield (Illustration of Path of Steepest Ascent)

Screening for Important Variables

The first step in many experimental, development or production problems is to find those few controlled variables having the most profound effect upon a response given that there are 10 or 20 or perhaps as many as 50 controlled variables. In essence the information obtained from the fractional factorial design is used to estimate the coefficients in the first order model

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \varepsilon$$

where k is a large number. Those controlled variables whose coefficients are found to be significantly different from zero are selected as the most important variables. The great concomitant value to the use of fractional 2^k factorials comes from the frequent repetition of the high and low levels of each controlled variable balanced across the many other controlled variables. This replication aspect of the designs greatly increases the ability of an experimenter to detect small changes in a response as a function of changes in a controlled variable. Of course the two-level factorial design can also be used to contrast the effect upon a response of the presence or absence of some qualitative controlled variable (such as the presence or absence of some bath treatment, chemical reagent or technique of handling) as well as the high versus the low level of some continuous controlled variable such as time.

The application of the 2^k factorial and first-order designs to the problem of screening for leading controlled variables requires a careful choice of the size of the change to be made in the level of each variable. There are also many different ways in which the 2^k factorial design may be fractionated and a choice of the proper fraction requires at least a sense of the simultaneous roles of some of the variables.

A particularly valuable reference describing the application of the two-level factorial and fractional factorial designs to the problem of screening for the important effects, which also includes a description of a rapid and informative graphical technique of analysis called 'Half-Normal Plots', is by C. Daniel, "Fractional Replication in Industrial Research," *Proceedings of the Third Berkeley Symposium*, Univ. of California Press, 1957.[19]

Recently, F. E. Satterthwaithe has suggested an experimental approach for screening for important variables called "Random Balance." In these experimental programs the number of experiments performed can be actually less than the number of controlled variables studied. The designs must be constructed to fit the particular needs of the problem, are not restricted to two levels for each controlled variable, and have a "built in" random element in their construction. The methods of interpreting the results of random balance programs have yet to be thoroughly explored.

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(See page 25)

useful approximations in defining

Single Sampling Attributes Plans*

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It is well known that the χ^2 distribution can be used to obtain Poisson probabilities. Thus the basic relation between the two distributions has been used by Peach and Littauer, among others, as a basis for developing attributes sampling plans.[1]

The same basic relation is used in this article to develop a formula which can be used effectively to develop single sampling attributes plans. It turns out that another kind of approximation can also be used which is sufficient for practical sampling plans. This approximation is simple and convenient to use, involves little time, and has wide application.

Two assumptions must be made, the first being the obvious one that Poisson conditions prevail. The second assumption is that there is a common risk, α, of rejecting superior (p_1) quality and of accepting inferior (p_2) quality. This assumption is not really very restrictive. In practice, one can usually redefine either p_1 or p_2 so that the assumption is met approximately, especially since a wide variety of values of α is available.

*Some of the work on this article was done while the writer was working under a Guggenheim fellowship.

TABLE I—Comparative Data on the Accuracy of the Three Estimating Formulas

α (%)		χ^2 tables	Formulas		
			(1)	(3)	(4)
50	c = 0	1.386	1.407	1.133	1.386
	c = 1	3.357	3.370	3.333	3.386
	c = 2	5.348	5.337	5.333	5.386
	c = 14	29.336	29.333	29.333	29.386
30	c = 0	1.561	1.570	1.517	1.561
	c = 1	3.536	3.524	3.517	3.561
	c = 2	5.529	5.520	5.517	5.561
	c = 14	29.519	29.517	29.517	29.561
20	c = 0	1.833	1.827	1.806	1.833
	c = 1	3.819	3.809	3.806	3.833
	c = 2	5.814	5.807	5.806	5.833
	c = 14	29.807	29.806	29.806	29.833
10	c = 0	2.408	2.381	2.429	2.408
	c = 1	4.422	4.413	4.429	4.408
	c = 2	6.634	6.426	6.429	6.408
	c = 14	30.428	30.429	30.429	30.408
5	c = 0	3.047	3.011	3.114	3.047
	c = 1	5.099	5.098	5.114	5.047
	c = 2	7.113	7.107	7.114	7.047
	c = 14	31.133	31.114	31.114	31.047
2	c = 0	3.932	3.908	4.146	3.932
	c = 1	6.048	6.116	6.146	5.932
	c = 2	8.083	8.133	8.146	7.932
	c = 14	32.134	32.145	32.146	31.932
1	c = 0	4.615	4.614	4.942	4.615
	c = 1	6.787	6.938	6.942	6.614
	c = 2	8.842	8.924	8.942	8.614
	c = 14	32.922	32.940	32.942	32.614

The following notation will be used:

p_1 = predetermined quality level such that the probability of rejection is α

p_2 = predetermined quality level such that the probability of acceptance is α

n = the sample size of a single sampling plan

c = the acceptance number of a single sample plan, i.e., the maximum number of defectives permitted in a sample for acceptance

$\chi^2_{2c+2,\alpha}$ = the χ^2 value corresponding to $2c + 2$ degrees of freedom and a probability level of α

The Formulas and Their Accuracy

Under the stated conditions it follows from an (approximate) formula given by Wilson and Hilferty[2] that:

$$n(p_1 + p_2) = 2c + 2 - \left(\frac{2}{3}\right)(1 - t_\alpha^2) + \left[\frac{12}{81\ (2c + 2)}\right](1 - t_\alpha^2) \qquad (1)$$

where t_α is defined by:

$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{t_\alpha} e^{-x^2/2}dX = \alpha \qquad (2)$$

As Table I shows, (1) reduces, with little loss of accuracy, to*

$$n(p_1 + p_2) = 2c + 2 - \left(\frac{2}{3}\right)(1 - t_\alpha^2) \qquad (3)$$

The second approximation, which was discovered *empirically* from a study of χ^2 tables, is that (using *natural* logarithms):

$$n(p_1 + p_2) = 2c + \ln\left(\frac{1}{\alpha}\right) + \ln\left(\frac{1}{1-\alpha}\right) \qquad (4)$$

This formula is exact for a c of zero; for other values of c it provides sufficiently good approximations for practical sampling plans.

*This approximation also follows readily from an equation given by Goldberg and Levine.[3]

TABLE II—Applications of Formula (4) to Representative Published Plans ($\alpha = 0.10$)

n	c	p_2	np_2	$n(p_1+p_2)$	np_1	$P(np_1)$	$P(np_2)$
460	0	0.005	2.30	2.4	0.10	0.905	0.101
775	1	0.005	3.875	4.4	0.525	0.902	0.101
1050	2	0.005	5.25	6.4	1.15	0.890	0.105
1330	3	0.005	6.65	8.4	1.75	0.899	0.102
1600	4	0.005	8.00	10.4	2.40	0.904	0.100
225	0	0.01	2.25	2.4	0.15	0.861	0.106
390	1	0.01	3.90	4.4	0.50	0.910	0.099
520	2	0.01	5.20	6.4	1.20	0.879	0.109
655	3	0.01	6.55	8.4	1.85	0.883	0.108
785	4	0.01	7.85	10.4	2.55	0.884	0.109
115	0	0.02	2.30	2.4	0.10	0.905	0.101
195	1	0.02	3.90	4.4	0.50	0.910	0.098
265	2	0.02	5.30	6.4	1.10	0.900	0.102
335	3	0.02	6.10	8.4	1.70	0.907	0.099
395	4	0.02	7.90	10.4	2.50	0.890	0.106
45	0	0.05	2.25	2.4	0.15	0.861	0.106
75	1	0.05	3.75	4.4	0.65	0.861	0.112
105	2	0.05	5.25	6.4	1.15	0.890	0.105
135	3	0.05	6.75	8.4	1.65	0.904	0.096
160	4	0.05	8.00	10.4	2.40	0.904	0.100
23	0	0.10	2.30	2.4	0.10	0.905	0.101
39	1	0.10	3.90	4.4	0.50	0.910	0.099
50	2	0.10	5.00	6.4	1.40	0.833	0.125
65	3	0.10	6.50	8.4	1.90	0.875	0.112
80	4	0.10	8.00	10.4	2.40	0.904	0.100

This is verified by Table I whose first column gives a set of values obtained directly from χ^2 tables. These can be considered to provide norms of accuracy in the sense that, for Poisson probabilities defined by:

$$\sum_{x=0}^{c} \frac{e^{-np}\,(np)^x}{x!} = \alpha \qquad (5)$$

np is approximately equal to $(\frac{1}{2})\ \chi^2_{2c+2,\ \alpha}$.

The table also gives the results obtained from equations (1), (3) and (4). The α values were selected so as to represent typical situations likely to be encountered in practice. Similarly, four different c values are considered, three small and one large.

According to the table, the difference is never more than 0.3 (in absolute terms) between the formula values and the χ^2 values. Using the χ^2 values as norms, (3) is seen to give nearly as good an approximation as (1) except for a c value of zero, in which case (4) gives the exact value. Moreover, it is generally sufficient for sampling plans to have an approximation correct to the nearest half-integer. For this reason formula (4), as stated above, is generally acceptable for problems of the kind considered here. In what follows, therefore, only formula (4) will be considered.

Applications

An immediate application of (4) is to compute p_1 values when p_2 values are given, as in the Dodge-Romig single sampling LTPD tables,[4] or to compute p_2 values when p_1 or (AQL) values are given, as in the MIL-STD-105-A tables.[5] This can be demonstrated with a selected group of Dodge-Romig plans representing a variety of p_2 values and a uniform α value of 10 percent.

The $n(p_1 + p_2)$ values were computed directly from equation (4), using the $\ln(1/\alpha)$ plus $\ln(1/1-\alpha)$ values available in Table I (for a c value of zero).

The results are recorded in Table II. The symbol, $P(np_1)$, refers to the (Poisson) probability of accepting when the quality is p_1, while $P(np_2)$ refers to the (Poisson) probability of accepting when the quality is p_2. These probability values are obtained from tables of Poisson probabilities given in Grant.[6]

Table II suggests that equation (4) gives an acceptable estimate of values of p_1 in the sense that $P(np_1)$ is generally quite close to $(1 - \alpha)$, (90 percent here). Even where the $(1 - \alpha)$ value is missed by a few percentage points, the sum of $P(np_1)$ and $P(np_2)$ is quite close to unity. This is all the estimating equation should be expected to do.

A more general and useful application of (4) is in constructing single sampling attributes plans. The assumptions are the same as before but, to determine n and c uniquely, a second equation is necessary. Ordinarily, this equation can be defined by specifying that $P(np_1)$ be $(1 - \alpha)$ or, alternatively, that $P(np_2)$ be α.

Some examples have been computed and summarized in Table III. All the computing equations given are based on equation (4); use is again made of the $\ln(1/\alpha)$ plus $\ln(1/1-\alpha)$ values available in Table I (for a c value of zero). No example is given for an α of 50 percent since then p_1 and p_2 are equal (to the median). An independent defining equation would be necessary to derive unique sampling plans for this case.

The first plan (A) in each set is the plan which fully meets the stipulated requirements for both $P(np_1)$ and $P(np_2)$. The second plan (B) in each set represents the plan with the next smaller c value (if one exists). The final plan in each set, usually the third plan (C), represents an optimal plan in the following sense: the sample size is as small as possible for a plan which fully meets or *closely approximates* the stipulated requirements.

The table verifies that computing equations based on (4) can be used to construct single sampling plans with the required properties. On the basis of these examples one should be able, with the aid of the logarithm values in Table I (for a c of zero), to develop a sampling plan in a few minutes. Procedurally, one would use trial-and-error methods, starting with a c value of zero and

TABLE III—Examples of Single Sampling Plans Constructed from Formula (4)

Case	α (%)	p_1	p_2	Computing Eq'n		n	c	$P(np_1)$	$P(np_2)$
1	1	0.02	0.08	$n = 20c + 46.1$	A	286	12	0.994	0.010
					B	266	11	0.991	0.012
					C	271	11	0.990	0.010
2	1	0.01	0.09	$n = 20c + 46.1$	A	146	5	0.996	0.010
					B	126	4	0.991	0.012
					C	128	4	0.990	0.010
3	2	0.02	0.08	$n = 20c + 39.3$	A	219	9	0.985	0.020
					B	199	8	0.992	0.026
					C	203	8	0.977	0.020
4	2	0.01	0.09	$n = 20c + 39.3$	A	119	4	0.992	0.019
					B	99	3	0.982	0.023
					C	101	3	0.981	0.020
5	5	0.02	0.08	$n = 20c + 30.5$	A	151	6	0.965	0.045
					B	131	5	0.949	0.051
					C	—	—	—	—
6	5	0.01	0.09	$n = 20c + 30.5$	A	71	2	0.965	0.048
					B	51	1	0.907	0.056
					C	70	2	0.966	0.050
7	10	0.01	0.09	$n = 20c + 24.1$	A	44	1	0.928	0.093
					B	24	0	0.787	0.116
					C	43	1	0.930	0.102
8	10	0.05	0.10	$n = 13.3c + 16.1$	A	189	13	0.901	0.102
					B	176	12	0.889	0.109
					C	—	—	—	—
9	20	0.01	0.09	$n = 20c + 18.3$	A	18	0	0.836	0.198
					B	—	—	—	—
					C	—	—	—	—
10	20	0.05	0.10	$n = 13.3c + 12.1$	A	92	6	0.818	0.190
					B	79	5	0.793	0.201
					C	—	—	—	—
11	30	0.02	0.08	$n = 20c + 15.6$	A	16	0	0.726	0.279
					B	15	0	0.741	0.301
					C	—	—	—	—
12	30	0.05	0.10	$n = 13.3c + 10.4$	A	37	2	0.717	0.286
					B	24	1	0.663	0.308
					C	—	—	—	—

NOTE: The dashes, which occur only with Type B and Type C plans, indicate that no plan is available in these categories.

then perhaps proceeding in jumps until the second equation, say, with respect to $P(np_2)$ is satisfied.

It is useful to compare the proposed procedure with that of Peach and Littauer. In their case plans must be worked out from the beginning;[1] the single exception is for an α value of five percent, for which some tabulated data is given.[7] The Peach-Littauer procedure therefore takes somewhat more time than the proposed procedure.

Other Direct Applications

Table III brings out an important fact that, in practice, is not considered as much as perhaps it might. As the B plans show, one can often effect a significant saving in inspection cost at a negligible cost in terms of protection. For example, Plan B of Case 1 misses being an acceptable sampling plan by a very slight amount. This is probably of little practical consequence, especially when one considers that, in applications, risk values can rarely be pinpointed in numerically sharp terms.

The procedure outlined here is directly useful in questions of this kind, that is to say, to determine whether significant savings in inspection cost can be effected with only slight sacrifices in terms of protection. The examples in Table III suggest that savings can ordinarily be effected except when the basic c value is zero (cf., Case 9).

The C plans also illustrate that it is sometimes possible to find a plan which fully meets the risk requirements, but at a smaller inspection cost than the plan one might first select. The procedure outlined here is also directly useful in questions of this kind. Ordinarily, one tries the next lower c value and, if this falls short, as in Plan B of Case 1, the problem can sometimes be solved by increasing the sample size slightly, as in Plan C of Case 1.

There are some cases in which this is not a feasible alternative. Thus, in Case 6, the original c value would have to be retained if the risk requirements simply had to be held. The only saving that can be effected in such cases is a reduced sample size which, in Case 6, involves a saving of just one unit.

It only requires a few minutes to look into questions of this kind; this would appear to be time well spent in view of the potential savings.

The data in Table III suggest that, with large initial c values, the c value can generally be reduced and, hence, also the n value; this would result in a significant saving with only a slight loss of protection. With small initial c values, however, it seems to be quite difficult to do this; this is particularly true of small α values.

These points should be helpful to those who develop single sampling plans, and they might well be helpful also to those working with established sampling plans. Even there it may pay to look into the possibility of using more economical plans, such as the B and C plans in the table.

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New Quality Control Center for Ford Motor Company

Ford Motor Company early in October unveiled a pioneer Quality Control Center where new cars are built under actual assembly conditions months in advance of public introduction so that any potential quality problems can be corrected long before the first car goes to a consumer (This issue's front cover shows a workman at the center checking the body of a 1959 Ford to make certain that all door and window openings are correct.)

J. O. Wright, Ford Motor Company vice president and Ford Division general manager, said the new Quality Control Center is the newest part of a three-phase quality program which includes *Quality Designing*, *Quality Building*, and *Quality Auditing*.

According to Mr. Wright, the Quality Control Center and pilot plant is the "hub and nerve center" of the quality program, where engineers and technicians set high quality standards which become the target of assembly plants throughout the nation.

"By adding this pioneer operation, we are in a position to know where our problems lie months before the first production car comes off the assembly line." He explained that each sample part is checked at the pilot plant far in advance of introduction. If the part does not meet the engineering specifications, it is sent back to the supplier for correction. If the trouble is incorrect design, the part is redesigned.

As parts pass the first check, they are assembled into a vehicle right on the pilot plant assembly line to check their fit in relation to other parts.

"For the first time in industry history it enables us, under one roof, to apply to the mass production process the precision and attention to detail that are the hallmark of skilled hand craftmanship. It is here that quality problems are detected early enough that the full resources of the company can be put to the solution in time to benefit the consumer and preserve the integrity of the product." The plant has a maximum capacity of only five cars a day, employs only 47 persons, and has more of an atmosphere of an assembly laboratory than an assembly plant.

The *Quality Building* phase of this program has its principle imbedded in the training advantages of the center, where months before assembly starts at the various plants, key production people receive classroom training on each operation and then perform the operation under actual conditions.

Mr. Wright explained the *Quality Audit* as a "careful auditing for quality of a scientific sampling of cars and trucks at assembly plants before shipment to dealers."

Finally, *Quality Design* attempts to improve the overall mechanical operation as well as improvements in finishes.

The IMPACT OF QUALITY on Today's Market*

W. C. BRICE

International Harvester Company, Milwaukee Works, Milwaukee, Wis.

It is a privilege to keynote this annual Quality Control Conference. As I understand the role of keynoter, he is not expected to contribute anything in the way of a technical approach to the problem at hand. It is his job to set the stage for the experts who will conduct the shirtsleeve sessions that follow him.

I appreciate the fact that I will not be expected to discuss such things as "applied sequential analysis," or "truncated sampling." To be honest, I don't even know if I pronounce them correctly. But that isn't important to me. I have people like our Chief of Inspectors and Quality Control Engineers (Foundry and Manufacturing) to wade through such things for me, and I expect them to come up with a practical, effective program of quality control through statistical methods. They did just that for me many years ago, and we are reaping the benefits today.

So I'm not going to discuss quality control techniques. And while it may come as a shock to the individual who assigned me the title of my remarks, we will only briefly touch on the "Impact of Quality on Today's Market." Rather, permit me to give you my impressions of two added responsibilities of the quality control engineer aside from his job of administering a plant's quality control program.

I won't dwell on the need for you to do your specific job. That's the purpose of conferences such as this; and your discussion leaders to follow can accomplish this end far better. Suffice it to say that none of us can afford to rest on our oars and drift with the current. We can't afford to sit back and gaze enraptured at the job quality control, for example, *is* doing for us without objectively scrutinizing our program for additional jobs it *could* be doing for us. Each of us must be constantly alert to new and better ways of doing business. Whether it is the development of an entirely different method or a revision of a true and tested method, we can't afford the luxury of assuming that what we are doing today is good enough to stand up to tomorrow's challenges.

Note that I do not say that a new way of doing things is the only answer to our problems. Sometimes the adaptation of a proven principle is more practical. An illustration of this might be the story of the modern business firm which hired a professional psychologist as personnel manager. His first job was to hire a secretary for the president. So with the boss looking on, the expert gave a psychological quiz to three feminine applicants.

"Two and two," began the psychologist.

"Four," replied the first girl promptly.

"It might be twenty-two," replied the second girl.

The third girl thought for a moment and then answered, "It might be four and it might be twenty-two."

The psychologist drew the president aside and said, "There you have the perfect example of the efficient, psychological way of hiring people. The first girl said the obvious thing; the second was suspicious; the third was cagey and wasn't going to get caught. Which do you prefer?"

The boss didn't hesitate a moment. "I'll take the blond with the blue eyes."

*Keynote address, Fifth Industrial Quality Control Clinic sponsored by the Milwaukee Section, ASQC, Milwaukee, Wisconsin, Mar. 14, 1958.

So you see there is a time and place for the new and revolutionary, but you just can't close your eyes to reality!

But back to my impressions of the two added responsibilities facing the quality control engineer. Bear in mind that these suggestions need not be confined to quality control engineers. My suggestions can be directed to all staff and service departments as well as to line supervision. But the nature of today's conference causes me to single out your group.

The first added responsibility facing the quality control engineer today is a broadening of perspective. I concede that we are living in an age of specialization. But it appears to me that too many specialists today operate as though the word "specialization" is synonymous with "limitation." I'm afraid that too few specialists look beyond the immediate objectives of their own sphere of activities, and consequently blind themselves to what we call the "Big Picture."

In my book, today's specialist must perform his function with one eye on his specialty and the other on the over-all activities of his company. There is no question in my mind that all of you subscribe to this. But I'm afraid that this philosophy has been relegated to our subconscious in our sincere efforts to perform our own specialties more efficiently. Now is the time to bring it forward again, dust it off, and apply it consciously and positively to our everyday activities. If there was ever a time when business and industry needed the most constructive thinking of all its people applied to all of its problems, the time is now.

Let me ask you a couple of questions along this line to illustrate my point. How long has it been since you have made a recommendation or suggestion on a problem which was not directly within the scope of your own responsibilities? Have you ever, when out on the floor analyzing a job prior to charting it, taken a good look to see if you could suggest a more efficient method of performing the operation? How long has it been since you offered a constructive suggestion to your safety supervisor? How long has it been since a materials handling situation attracted and held your attention? Have you ever offered your industrial relations manager the benefit of your *thinking* on a labor relations problem?

Now, job planning, safety, stock movement, and labor relations are prime responsibilities of other department heads, and technically you need not concern yourself with their problems. But here the specialist can enter the Big Picture. Your suggestion to these department heads could set the wheels of these other specialists in motion. Granted that you are not thoroughly versed in these other fields. That can be an asset! Your fresh approach, unhindered by tradition or past practice, could well provide the stimulus for some imaginative thinking on the part of the experts.

The word expert always reminds me of the small town constable who was also the local veterinary. His wife answered the 'phone one night and when the man asked to speak to her husband she asked, "Do you want my husband in his capacity of veterinary or a chief constable?" "Both, Madam," came the reply. "We can't get our dog to open his mouth, and—there's a burglar in it."

So I think we too can do two things at the same time.

I don't suggest that you all run out of here and usurp the authority of your engineering or production people. You are much too busy for that. But you are not too busy, and neither am I, to take a side glance occasionally at what is going on in fields not directly related to our own specific interests. We owe it to our organization and we owe it to ourselves to broaden our outlook to the point where we can become ever more valuable to our company.

So much for your first added responsibility. Here is my idea of a second responsibility you can assume in the normal course of your work. It's of equal importance to the first. I believe you all have a responsibility to acquaint employees with, and stress to them, the direct relationship between quality work and job security. I believe we have been negligent in driving this basic fact home in a more personally related way. We have too often approached this problem of quality workmanship from the negative aspect. We have employed the threat of discipline and we have pointed up the cost to the company resulting from excessive scrap and rework. We should have been relating scrap to the reaction of the customer, his unwillingness to give us another chance to serve him—the resulting loss of sales, the subsequent decreasing of demand for our product—the reduced production schedules and the consequent need for less employees. Surely that's an over-simplification. But I challenge anyone to dispute the fact that this chain reaction does occur to a greater or lesser degree.

I am not suggesting a fear campaign among our people. I am suggesting that you men who are at the scene, and who have the finest opportunity, help us instill in the minds of our people the understanding that the quality or lack of it which they build into the finished product, is their personal, direct contribution to their own job security or insecurity. Forgetting for the moment that scrap and rework is costly and can place us in a poor competitive position, the attitude of King Customer toward us and our products, dictates in the end, how many people we can keep gainfully employed. King Customer is a wonderful guy. But at the same time he is completely and absolutely ruthless. He doesn't give a hoot whom he hurts when he buys or doesn't buy. Our problems are of no concern to him. You can't get him to sit and listen to your story about how much care you take in building your product, while he holds a defective part in his hand. I wish each employee in industry could spend just one day out in the field with the service man and the customer whose machine is malfunctioning because of a defective part! I'm convinced that the employee would never (and that's a long time—never) be responsible for letting scrap get out of his department.

So, I ask you to give us an assist in getting this story across. You will be performing a service to yourself your fellow employee, and your company.

Let me close with this observation. Quality control has proved it can meet the demands we make upon it. Management needs this tool today as never before. We at International Harvester are thankful that we are entering this critical period with some experience behind us.

I look for quality control to play a major part in maintaining whatever advantage we now have on our competitors in the fields of construction equipment, motor trucks, and farm equipment. I look for my quality control engineers to develop new and revolutionary applications of their specialty. I expect them to exercise greater imagination and inventiveness than ever before. And finally, I expect them to look at their problems and plans with one eye on the Big Picture.

1959 Middle Atlantic Conference

"Balanced Perspective equals Successful Quality Control" is the theme of the 1959 Middle Atlantic Conference to be held at the Traymore Hotel, Atlantic City, N. J., on Feb. 6-7, under the sponsorship of the Delaware section of ASQC.

The highlight of the conference will be a panel discussion on the subject "Quality Control—Increasing its Effectiveness and Professional Status." Panel members are from the upper echelon of Who's Who in quality control. Prof. E. R. Ott of Rutgers University is the moderator. Panel members are: Dr. J. M. Juran, Consulting Management Engineer; Dr. A. V. Feigenbaum, Manager of Quality Control, General Electric Co.; O. E. Johnson, Vice President-Manufacturing, Bristol-Myers Products Division; and G. Fromm, Vice President-Manufacturing, International Latex Corp. This will be a conference-wide session and one that no one will want to miss.

A well balanced program of interest to the ladies and also a program for the children will be provided. This, together with the technical sessions, will make it a stimulating and altogether worth while week end for the entire family at beautiful Atlantic City.

Registration blanks and detailed program may be obtained by writing J. L. Freeman, General Motors Corp., Boxwood Road, Wilmington, Dela.

ASQC Convention Exposition Chart

13TH ANNUAL CONVENTION AND NATIONAL ALL-INDUSTRY QUALITY CONTROL & PRODUCTION EXPOSITION
CLEVELAND PUBLIC AUDITORIUM
MAY 25-27, 1959

Q to Quality

Did you ever stop to think of the work in piecing together a big convention and trade show? It takes months of planning to make the pieces all fit together like a handsome jigsaw puzzle. A great many uneasy moments are spent wondering if such and such a speaker will consent to be on the program, or "Why doesn't this company have a booth in the Exposition?"

There are also many happy and comforting moments, when you feel well satisfied with your accomplishments. Your convention committee has just hit one of these milestones along the "Q to Quality" way.

Word comes from John J. Riordan, Staff Director, Inspection and Quality Control Division, Office of Secretary of Defense, Washington, D.C. that this top government organization will participate in our ASQC convention in Cleveland, May 25-27, in a major way with a "Department of Defense Quality Control Symposia." Fourteen of the Defense Department's top experts, collected from various bases throughout the United States, will be sent to Cleveland to participate in the symposia, which will be divided into four sessions.

The first session on "Military Progress in Quality Control for 1958," will have Mr. Riordan as Chairman. With the turning of military power to rockets, missiles and outer space, this should be extremely interesting to everyone. Speakers at this session will be Col. E. J. Gibson, Chief, Procurement Division, Deputy Chief of Staff (Logistics), Department of Army; Capt. George L. Heap, Assistant Chief of Naval Material, Department of Navy; and Col. Joseph G. Schneider, Chief, Quality Control, Air Material Command, Department of Air Force.

"New Developments in Military Food Inspection" is the subject of the second session. Col. Richard L. Lewis, Chief, Inspection Division, Military Subsistence Supply Agency, will be the Chairman of this session. Speakers will be Richard P. Bartlett, Jr., Agricultural Marketing Service, U. S. Department of Agriculture; Col. Elwin R. Prather, Veterinary Corps, Department of Army; and Gordon J. Keefe, Office of Quartermaster General, Department of Army.

The third session will jump to missiles and perhaps even to outer space as the subject "Quality Control and Reliability of Military Equipment" is discussed. Dr. Max Astrachan, Air Force Institute of Technology, Wright-Patterson Air Force Base, will be the chairman. Speakers will be E. J. Lancaster, Staff Assistant for Quality, Ballistic Missiles Office, Inglewood, California; Lt. Col. M. L. Raines, Deputy Director, Industrial Division, Army Ballistic Missile Agency, Huntsville, Alabama; and Com. Glenn G. Estes, Jr., USN, Bureau of Ordnance, Department of Navy.

The final session will be a continuation of the third, with John J. Crowley, Executive Assistant to the Senior Vice President, Engineering, General Dynamics Corp., heading the speakers and being followed by Col. O. C. Griffith, USAF, Quality Control, Air Material Command, Department of Air Force.

The convention this year again will cover over a score of subjects with a program of nearly a hundred speakers to relay findings and conclusions from many long periods of practical study in their respective fields. Just to give us a tingle of accomplishment that we are lining up a most successful and worthwhile program, we'd like to mention a few of the speakers: W. J. Youden, Department of Commerce, National Bureau of Standards, Washington, D.C., who is in the Chemical Division, will talk on "Problems of an Experimenter"; Dr. Joseph Juran, Management Consultant, New York City, whose subject is "Management Field"; Harold F. Dodge, formerly with Bell Telephone Laboratories and co-author of the famous Dodge-Romig Sampling Tables, who speaks "On Sampling Inspection Plans"; Irving W. Burr, Purdue University, Lafayette, Ind., "Standardization Of Quality Control Terms and Symbols." (Both Mr. Dodge and Mr. Burr are members of ASQC's Standards Committee.)

Now turning to the National All-Industry Quality Control & Production Exposition, which is one of the features of the ASQC convention. Among the early birds reserving exhibit space are: L. S. Starrett Co., Athol, Mass., who will display a complete line of precision and measuring tools; Monroe Calculating Machines, Inc., Orange, N. J., calculators and similar equipment; International Business Machines, Inc., quality control equipment; B. C. Ames Co., Waltham, Mass., measuring instruments; American Cystoscope Makers, Inc., Pelham Manor, N. Y.; Dow Mechanical Corp., Thompsonville, Conn.; Elliott Service Co., Inc., Mount Vernon, N. Y., management services; and Sheffield Corp., Dayton, Ohio, instruments and controls.

This year for the first time, the various technical sessions will be staggered so that you will have ample opportunity to view the exhibition at your leisure during the normal working day. Gone will be the hectic dash through the exhibits just before or just after the luncheons and technical sessions.

You still have time to reserve space. Just write for prices and locations to: Andrews, Bartlett and Associates, Inc., 1849 W. 24th St., Cleveland 13, Ohio.

As you can see, the 1959 ASQC Convention and Exposition is rapidly gaining momentum. Plan NOW to attend. Headquarters will be at the Cleveland Hotel, with the entire convention program held in Cleveland's huge Public Hall.

Remember, it's "Q to Quality". See you in Cleveland!

What's New?

ROY A. WYLIE, *Editor*
Ampex Corporation

P-12-7—A new high-performance Reflectoscope, Model UR-600, has been introduced. The UR-600 incorporates advanced pulser and receiver circuitry assuring greater sensitivity, and higher resolution at no sacrifice of linear response or dynamic range. A variable pulse repetition rate facilitates high speed scanning of small parts. Brighter video trace on the edge-lighted CRT screen makes for easier reading in daylight with faster interpretation of indications. The instrument may be used for both contact and immersion testing with one or two search unit techniques. It may be fitted with an automatic alarm system by adding the Sperry RA Monitor. Self-contained in an aluminum case, the UR-600 weighs only 75 lb., and can be carried to any point where testing is required. Skids on the case facilitate movement over shop floors. A separate accessory case accommodates cables, search units, reference blocks and related equipment. Operating controls are concentrated on the front panel. Test frequencies are 0.4, 1.0, 2.25, 5.0 and 10.0 megacycles. Power requirements are 110 or 220 volt, 50/60 cycle A.C., 190 watts, single-phase. The instrument may be obtained through commercial testing services or by lease as well as by purchase. The Reflectoscope is widely used to locate and identify discontinuities and inhomogeneities, whether on the surface or within the structure of materials. It is also used to determine differences in the structure and physical properties of materials, and for measuring thickness of material from one side. It may also be employed for inspecting the structural integrity of welds and bonds, the effects of wear upon machine components and for fast, reliable inspection of machinery to shorten downtime by eliminating the need for dismantling.

★ ★ ★

P-12-8—The Air-O-Limit Preload End Play Gage, a quick-responding, highly accurate gage for checking the preload and end play of ball bearings is now available. Checking both statically and dynamically, this gage determines the relative "face flushness", commonly called "stick in" and "stick out", of miniature and instrument size ball bearing races, such as those used in aircraft instruments and controls for guided missiles. The Air-O-Limit principle of measuring back pressure created by restriction of air flow is used to check the position of the inner race relative to the outer race under varying axial loads (preload), and the actual axial displacement of the inner race under load reversal of a given magnitude (end play). Bearings from 0.040 in. bore through 1 in. OD can be checked to a direct reading of 20 millionths of an inch on the preload scale, and five ten-thousandth of an inch on the end play scale. The heart of the preload gage is a combination of free-floating upper and lower pistons which ride in air bearings without friction. The air bearings permit minute axial movements of the bearing inner race under varying preloads, to be reproduced faithfully by the pistons and indicated by the sensitive air gaging circuit. The bearing inner race can be rotated at high speeds. End play is checked by means of a self-zeroing attachment containing a 0.015 in. range Air-O-Limit cartridge and appropriate dead weight loading units in combination with interchangeable inner tooling. This attachment is mounted above the upper gaging spindle.

★ ★ ★

P-12-9—Quantity testing of vacuum tubes to mil specifications is now possible with the Model 1128 Jackson Automatic Tube Tester. The unit was specifically developed to meet requirements of speed, accuracy, and versatility for 100 percent reliability testing programs in critical military applications. Designed for operation by unskilled personnel, the Model 1128 tester performs complete dynamic tests on up to 25 tubes at a time, at approximate rates of 7 to 10 seconds per tube. It handles most types of pentodes, triodes, diodes, and neon regulators. The tubes are prearranged for rapid testing in specially designed adapter trays that slide into the test rack of the unit. Testing is determined on a go/no-go basis. Provision is also made for pinpointing specific ele-

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TEXTILE DIVISION NEWS
9TH ANNUAL CONFERENCE, JAN. 29-31

The 9th Annual Conference of the Textile Division will be held on Jan. 29-31 in Charlotte, N. C. Papers to be presented cover the application of statistical control methods to textile manufacturing activities ranging from the processing of raw fiber and the manufacture of synthetics through fabric and garment manufacturing. In addition, study groups made up of industrial representatives will meet to discuss quality control problems and standardization in garment manufacture, cotton raw stock, staple fiber yarn, picker laps, sliver and roving, and fiber imperfections.

A series of papers covering basic statistical quality control methods is also scheduled. This series is in the form of instruction intended to familiarize newcomers to the Quality Control field with the fundamental techniques of sampling, data analysis and charting. Speakers for this series are experienced instructors for statistical methods and are associated with consulting firms, colleges and universities.

Headquarters for the conference is Hotel Charlotte. Detailed information on the program and registration can be obtained from L. I. Horner, Celanese Corporation of America, P. O. Box 1414, Charlotte, North Carolina.

ments of a tube failure. A totalizer indicates number of tubes failing to meet each test. Test program and specifications are fed to the machine by a separate AMP patchboard for each tube type, thus it is quickly converted from one tube type to another. Stepping sequences can be fully automatic or performed manually. The design includes a unique self-proving feature which permits rapid checkout of all measuring circuits. Extensive use of plug-in type components and hinged circuit panels provide easy access for servicing. The unit operates on standard 110v, 60-cycle, single phase power. Depending on specific modifications required by the user, the price of the Jackson Automatic Tube Tester ranges between $20,000 and $25,000.

★ ★ ★

P-12-10—The battery-powered Type 170 Microtrol Transistorized Indicator is a rugged and portable indicator, providing full-scale ranges of 0.0006 in. and 0.006 in. The unit is housed in a gasketed, die-cast metal case for maximum utility under the most severe environmental conditions. Long-life standard mercury cells ensure reliable operation. In an emergency, ordinary "AA" pen light cells can be used. A single magnification adjustment calibrates both ranges simultaneously and zero-setting for both ranges is provided by the advanced circuit techniques employed. The transistor amplifier circuit offers complete freedom from drift. No voltage adjustment for battery aging is required. The wide-range electrical zero control (0.003 in.) ensures minimum set-up time by eliminating the need for precise mechanical positioning of the gage head. On the high-magnification range (7700×) the ten-millionths graduations on a scale length of 4.6 in. provide readability to better than five-millionths of an inch. For the first time, gage laboratory accuracy and sensitivity are available in a completely portable unit, rugged enough for the most severe shop conditions and accurate enough for the most critical gaging applications. The Microtrol Type 170 Transistorized Indicator is furnished with a sensitive low-force gage head which, together with a complete assortment of mounting adapters, is securely retained in the cover of the indicator when not in use. Short delivery time and attractive prices are afforded by the advanced production facilities utilized for the printed-circuit construction.

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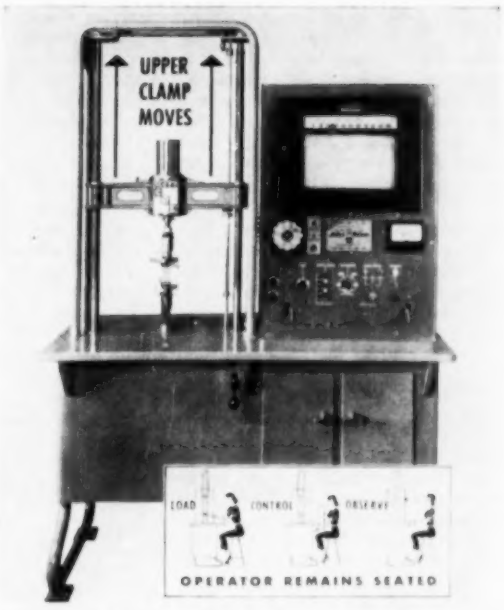
P-1-1—A new design concept makes possible, for the first time, a constant-rate - of - extension tester of high precision at moderate cost. The Model CRE Tensile Elongation Tester provides constant extension of the specimen by an upward moving crosshead which pulls the top holding clamp from the lower fixed clamp at uniform speed (any rate, as selected, from 0.05 in. to 20 in. per minute), to a length of extension up to 70 in. of crosshead travel. The automatic electric weighing system measures the resultant force and the registration of the stress-strain curve is permanently charted on a visual recorder. Ratio of chart travel to crosshead upward travel may be varied to magnify the stress-strain curve as much as 400 to 1, permitting analysis in detail of ultimate tensile yield point elastic limit and other variables. A basic CRE tester "tailored" for a particular production test operation can be obtained complete at low cost and to this basic tester can be added a variety of optional features for maximum laboratory versatility. These may be included initially or added at any time later in the field by the user's non-technical per-



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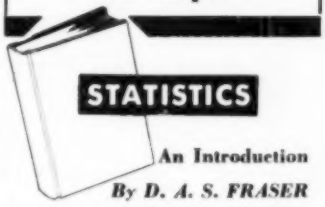

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sonnel. The CRE tester has capacities from 0-0.5 lb. to 0-1,000 lbs. or 0-25 grams to 0-500 grams tensile. It is a self-contained unit, floor mounted, free-standing, with levelizer feet; and requires only a single power input. The mechanical drive is automatically self-reversing to return the crosshead to the starting position. All controls are within reach of the operator while seated. More than 150 clamps and fixtures for holding all types of materials in conformance with standard as well as ASTM, ISO, Government and Industry test methods are available from the manufacturer.

★ ★ ★

P-1-2—The "Datamatic Jr." Weight Recorder is a new device which graphs, averages, and totalizes weights of small packages. Variations from normal to zero are graphed onto a 6 in. strip chart and the recorded weight is indicated on the top or front of the instrument. A Shadograph Scale is illustrated, but other Checkweight Scales or Balances can be attached. Strip chart plus and minus values are controlled by the sensitivity of the attached scale. The "Datamatic Jr." can be suspended under package lines or placed on a bench or table with the scale. The scale may be remotely located if necessary. Dimensions of the steel case are 14 × 14 × 18 in. deep.

★ ★ ★

P-1-3—A pneumatic trend recording Industrial Gas Chromatograph has been announced by Beckman. The new readout system permits the advantage of continuous easy checking of the components of interest as well as offers a major step forward in controlling process operations by cascade control through chromatography. Several pneumatic miniature recorders present analysis data. Some of these recorders are two-pen units which trace trend concentrations of two components. Another recorder traces a chromatograph of the analysis for use in calibrating and adjusting the instrument. Analysis by the standard chromatograph results in an electrical signal output for each component of interest. The signal is transformed by a transducer to a pneumatic signal proportional to the quantity of components. When the signal into the transducer reaches a maximum, the transducer freezes at the maximum; simultaneously a timing device programs the opening and closing of the valves to the pneumatic receiver and memory units. This timer also programs the restoration of the transducer system to operation from the frozen position after the peak value is properly stored. The pneumatic signal for each component is transmitted from the pneumatic memory system to the recorder, resulting in a quantitative trace of the signal peak. The memory unit maintains pressure so the signal to the recorder continues when the electrical signal to the transducer returns to zero. This gives a continuous trend trace to the component concentration. Each component of interest is analyzed and recorded in this manner. Continuous line trace of each compoent of interest gives at-a-glance information of concentration trends in the process. There is a single curve for each component. This allows the measurement of a critical component to be used as a control point for the operation.

New Literature Available

L-12-5—CSI Catalog No. 59, which contains illustrations and brief descriptions of sixty different testers or equipment is now available. The testers and equipment are used for testing adhesives, cement, insulation, metals, paper, plastics, rubber, textiles and fats-wax.

♦ ♦ ♦

L-12-6—A brochure, listing uses, temperatures and prices of Thermopaper and Thermotube disposable paper temperature indicators, is now available. These indicators measure temperature by exhibiting an irreversible color change when subjected to predetermined temperatures. Speed of response is less than a tenth of a second and accuracy is one percent.

♦ ♦ ♦

L-1-1—Three new MB bulletins describe vibration testing systems for the aero-space industry. Bulletin No. 425 covers vibration testing for sinusoidal and complex motion testing with force ratings from 1200 to 2500 lbs.; Bulletin No. 435 covers ratings from 1750 to 5000 lbs.; and Bulletin No. 470 covers the range from 7000 to 25,000 lbs. Detail specifications of each group of the components of the system as well as system performance are included in the bulletins.

♦ ♦ ♦

L-1-2—The availability of a new 175 page catalog illustrating and describing some more than 450 different pieces of apparatus and instruments has been announced by Libline, Inc. The catalog illustrates and describes such items as: Constant temperature baths, drying ovens, environmental units for humidity, altitude and low temperatures, an extensive line of petroleum testing equipment, sectional laboratory furniture, bench and floor model centrifuges, ALUMALOY clamps, walk-in ovens, reach-in ovens to 1000°F, incubators, incubating rooms, refrigerated baths, constant temperature cabinets, serological baths, meters, humidity indicators, and other useful apparatus and equipment for the laboratory and plant.

♦ ♦ ♦

A revision of the Directory of U. S. Government Inspection Services and Testing Laboratories published in 1951 is now available. Included are up to date listings of the major inspection services and testing laboratories of all Federal Government agencies, with the exception of facilities devoted exclusively to research and development programs. Copies may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. at $1.00 per copy.

section briefs

ALLENTOWN-BETHLEHEM . . . Our regular meeting was held on Nov. 12 at the Hotel Traylor; attendance was very good. In addition to the guest speakers, the section also was host to a group of students from the Penn State Extension in Allentown. These students are studying statistics and we were happy to have them with us so that they could see statistics applied in industry.

We were fortunate to have two very interesting and capable guest speakers. Vince Markley of Western Electric gave an excellent talk on sampling plans. Next on the agenda was Sut Munroe of Bell Telephone Labs who made a very graphic presentation of tolerance problems.

Dave Hilder briefly discussed the results obtained from the section's professional questionaire, a copy of which was handed out to all present.

BALTIMORE . . . At the well attended November meeting an interesting discussion on "Training for QC" was presented by Hardy M. Cook of Western Electric Co., Henry Ellner of Edgewood-Maryland Army Chemical Center, and Clifford E. Hughes of Rheem Mfg. Co. They presented programs that their organizations had developed to train personnel in QC activity.

The executive committee met on Nov. 4 and decided to have a "Ladies' Night" dinner meeting on Feb. 20. Colston E. Warne, president of Consumers' Union, will speak on "Consumers quality." Ervin F. Taylor, chairman of the Society's Bibliography Committee, explained that the first phase in establishing the classification index system for QC literature has been completed. A committee, on the local level, will be formed to assist in the classification of the various subjects.

BATTLE CREEK-KALAMAZOO . . . A problem night was held recently. A panel composed of representatives from the metals, food, pharmaceutical, paper, and wood industries as well as civil defense discussed the various problems.

Plans are being discussed for a spring forum and a plant tour.

BOSTON . . . A very successful fall lecture series entitled "An introduction to QC" and sponsored by the section was concluded Nov. 19. Dave Harrigan, chairman of the education committee, and his committee members are to be congratulated for the splendid job done. The lectures were delivered by Maynard Renner of Dewey-Almy Chemical Co. and William S. Hertzmark of Raytheon Mfg. Co. Sixty-five enrollees received certificates at the completion of the course.

BUFFALO . . . On Nov. 24 John W. Lally of the Wurlitzer Co. spoke on "How management sees the benefits of QC" and Sigmund P. Zobel of the Carborundum Co. discussed "Basic elements of SQC."

The Feb. 10 meeting will be a joint session with the St. Catharines section. The speaker will be Dr. A. V. Feigenbaum and his subject will be "Total quality control."

BUZZARDS BAY . . . Leonard A. Caplan, United States Time Corp., was guest speaker at the Nov. 13 meeting. His subject was "Responsibility for quality" and he discussed organization of the QC department, conflicting problems shared with other service and production departments, and important functions to be properly discharged in order to achieve success. He also showed how QC can become a valuable management tool if it is integrated into the company as a powerful adjunct to the sales, accounting, production, engineering, and inspection departments. A lively question period concluded the session.

CHARLESTON . . . The attendance at our recent meeting was most gratifying—over one hundred. A Royal McBee LGP-30 digital computer was displayed. The overall success was due to the efforts of J. L. Massau, C. M. Drummond, and P. A. Rhudy—all section members.

CHATTANOOGA . . . At the November meeting, R. Boyd, supervisor of computer research at TVA, discussed applications of computers at TVA. A tour of TVA's new IBM 704 followed.

The University of Chattanooga will be host for a one-day QC conference on Feb. 20. All those interested in keeping abreast with current developments in QC are invited to attend.

CHICAGO . . . The two-day training program was attended by approximately 100 people. As in previous years, the students were subjected to two days of rigorous statistical training by Lloyd Knowler of Iowa State, John A. Henry of the University of Illinois, and Gayle McElrath of the University of Minnesota. J. Y. McClure, Convair-Fort Worth, was the luncheon speaker. He stressed the cost cutting advantages of QC and the importance of realistic applications in industries with complex items such as the aircraft industry.

CINCINNATI . . . At the November meeting Prof. Merrill M. Flood, University of Michigan, gave an interesting talk on "Mathematical techniques of problem solving." This was a joint meeting and was sponsored by AIIE.

The opening address at the Jan. 31 conference will be made by Father O'Connor, president of Xavier University. One of the outstanding speakers at this conference will be Donald MacConley, president of the Paper & Printing Quality Control Co. and past management consultant to government and industry in Asia and Europe. Mr. MacConley has been quoted and featured in leading stories in "Fortune" and "Business Week" magazines.

CLEVELAND . . . The section was most fortunate on Nov. 7 to have the opportunity to visit the chemical and physical research center of Standard Oil of Ohio. One of the most interesting pieces of equipment was the laboratories' tracking station for our satellites. We were shown the patterns the various missiles had made. After the plant tour, a most enlightening talk was given by Dr. David Frazier.

On Nov. 17 the section successfully launched its fall educational program. A six-week course in "A simplified presentation of analysis of variance and experimental design" was successfully started with Dr. J. N. Berrettoni and H. M. Wadsworth, both of Western Reserve University. The final windup of the course will be given by Dr. F. C. Leone of Case Institute of Technology.

COLUMBUS . . . A panel discussion on "How can QC contribute to manufacturing" was held Nov. 18 at the Timken Roller Bearing Co. The panel was composed of: two manufacturing superintendents—Gerry Van Steyn of Kimble Glass Co. and Jack Simon of Jeffrey Manufacturing Co.; two QC managers—Robert Coffman of Timken Roller Bearing Co. and Gordon Olsen of Standards Ternsted Div., GMC. The moderator was Roy Cowin of Kimble Glass Co.

The discussion dealt with day-to-day problems and improving QC services. A lively question and answer period prevailed throughout the program. I believe everyone attending was able to glean something worthwhile from this session.

The Feb. 18 meeting will be held at Kimble Glass Co. The speaker, Max Astrachan of the U. S. Air Force Institute, is well qualified in the QC field and will talk on "Current operation research programs."

CORNING-ELMIRA . . . Fifty members and guests enjoyed a delicious buffet style dinner at the Baron Steuben Hotel on Nov. 18. Speaker for the evening was George Levenbach of the Bell Telephone Laboratories, Allentown, who addressed the group on "Life testing: statistical and practical problems."

Tentative plans were also announced for two educational classes to start about Apr. 1. The courses are: "Process capability studies in production" and "Reliability studies in life testing" and will be conducted by professors Henry Goode and John Kao of Cornell University.

S. J. Cheery, past section chairman, presented an account of the activities of the Corning-Elmira Council of the Scientific Societies which is currently working with the Elmira School District. This council, of which the section is a member, has recently been established to assist the local school districts in promoting and supplementing mathematical and scientific education.

CUMBERLAND . . . John R. Gilman, manager of QC at Bay State Abrasive Products Co., addressed the group at the November meeting. His talk concerned "Quality reports to management." Various types of reports and charts used at Bay State were discussed.

DALLAS-FORT WORTH . . . Dorian Shainin spoke to a full house at the Nov. 13 meeting. The subject of his talk was "How managements have drastically reduced operating costs." This was the last stop on his circuit tour of the four Texas sections. He is well known in this area and 90 people were on hand to greet him. This was our largest attendance so far this year.

DAYTON . . . On Nov. 6 the section held its second technical meeting of the year at the Moraine Products Division auditorium. The speaker was O. H. Bishop, Reynolds Metals Co.

The introductory course in QC techniques has been completed and certificates will be awarded to 12 participants. Plans are now being made to hold an advanced course.

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ELLIOTT HI-VISION PROGRAM

(See page 33)

On Feb. 5 the first dinner meeting of the year will be held with Dorsey Dean of the Firestone Rubber Co. as the speaker of the evening.

DELAWARE . . . A very successful meeting was held on Nov. 6. Clement Bason discussed various types of sampling plans and their operating characteristic curves. Interest in this subject was displayed by the large turn-out.

The main speaker of the evening was Henry Brenner, president of Home Testing Institute. His topic was "The establishment of QC standards through the use of market research—a simple way to maximize net profits." He discussed some of the techniques used in evaluating consumer preference and some of the pitfalls encountered in analyzing the data. It was brought out that the consumer should play a major role in establishing QC standards. There was a large turn-out and a terrific question and answer period followed Mr. Brenner's presentation.

No meeting is scheduled in February as the Mid-Atlantic Conference is being hosted by the section. It will be held Feb. 6-7 at Atlantic City.

DENVER . . . On Nov. 13 Abram Raich of the Colorado Fuel and Iron Co. talked on the progress of SQC in India. Abe, who spent some time as a UN representative in India in 1957, presented a number of interesting slides and also gave us a rundown on the application and interest in SQC.

ERIE . . . The Nov. 19 meeting was held at the David Mead Inn, Meadville, with 35 people attending. The program began with a discussion by J. Keller, American Viscose, on the use of binomial probability paper to determine whether lots rejected by a sampling plan have been adequately sorted by 100 percent inspection. After dinner, Mr. Zanhiser of Talon, Inc. led a panel discussion on the efficiency of 100 percent inspection vs. sampling inspection. Panel members were W. Myers of Kaiser Aluminum, A. Breed of General Electric, and D. Lehman of Talon, Inc.

EVANSVILLE-OWENSBORO . . . Dorian Shainin, director of statistical engineering for Rath & Strong, Inc., was the speaker at the November meeting. Mr. Shainin presented a very interesting program.

Edwin Shecter, QC supervisor for the Sonotone Corp., will be the speaker at the Feb. 17 meeting to be held in Evansville. Mr. Shecter, who is chairman of the Metropolitan section of ASQC, will speak on the subject "Narrow limit gaging."

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5th National Symposium on Reliability and QC Special Award Winners

Announcement of several special award winners was made at the recent 5th National Symposium on Reliability and QC in Electronics.

Ralph Brewer, General Electric Co., Ltd. of Wembley, England, became the first person outside of the U. S. to receive the National Reliability Award, given for the best technical paper presented at last year's symposium held in Washington, D. C. Mr. Brewer's paper depicted remarkable improvement in electronic tube reliability. He is a member of the senior scientific staff of the research laboratories of GE.

The Electronics Division of ASQC announced that its 1958 Award will be presented posthumously to Dr. Richard C. Carhart, widely known physicist, who died December 9, 1956. Dr. Carhart was selected by the group for his outstanding technical contributions in the field of reliability and QC—particularly in relation to military electronic equipment. A plaque symbolizing the honor will be accepted by Dr. Carhart's widow, Mrs. Mary Carhart, at a ceremony in California to be arranged by Lockheed Aircraft Corp.

GEORGIA . . . The Atlanta group recently completed a basic course in SQC. The course, co-sponsored by the Georgia Institute of Technology, was limited to 25 persons and already there is a request for another course. The instruction was conducted for 2½ hours each Monday night for ten weeks and was under the direction of Dr. J. J. Moder, Jr.

On Feb. 16 the Atlanta Group will discuss "Practical application of basic SQC." Some of the students in the recent course in basic SQC will present examples and problems from their industry.

GREATER DETROIT . . . Again carrying on in the best of traditions, the 7th annual dinner dance is planned for your enjoyment. The dinner dance, to be held Jan. 31, will be a thoroughly non-technical fun session, designed for entertainment alone.

This annual get-together has become an important social occasion for each of our members. This year's party will not deviate from the past in complying with these specifications: **A**ppetizing cocktails, **S**cintillating music, **Q**uality "plus" food, **C**ongenial conversation. Make your reservations early to avoid disappointment.

GREATER MUSKEGON . . . Slightly over 250 members and guests attended a joint meeting with ASTE. The dinner meeting was held at the Doo Drop Inn on Nov. 13. The DoALL Company's "Story of the cutting edge" was pictorially and capably presented by their director of educational research, C. G. Schelly. Part of the story was told by a 43 foot historical panorama. Merrill Vailey of ASQC and Jay Retsema of ASTE, chairmen of their respective sections, presided at the meeting. Many students from the Muskegon Community College and area high schools, who had participated in the ASTE Student Industry Day earlier in the year, came to hear the interesting presentation.

Herbert Jones, professor at Western Michigan University, will be guest speaker at the annual "Ladies' Night" program to be held Feb. 12.

HAMILTON . . . The second annual jointly sponsored QC forum, which was held at the Scottish Rite Temple on Nov. 13, was voted an outstanding success by those in attendance. Despite the inclement weather, some 120 persons—many who travelled long distances through rain and fog—were on hand to hear the speakers. P. B. Proctor (who replaced scheduled speaker Simon Collier), Paul S. Olmstead, and Ben Lloyd all faced an interested audience. A splendid dinner rounded out the evening's events, which saw much interest shown in the display of text books. Many thanks to the speakers and the University of Western Ontario section for the splendid cooperation in this venture.

On Feb. 10 we will travel to St. Catharines for a joint meeting with the St. Catharines section. Dr. A. V. Feigenbaum will be guest speaker.

HAMILTON-MIDDLETOWN . . . The monthly meeting of Nov. 11 proved to be unanimously successful by presenting a panel discussion on selling a QC program. By presenting brief skits, DuWayne Carlson demonstrated what not to do when selling a QC program. Then he led a panel of men representing research, management, sales, and production to give their opinions of the skits from their experiences in their respective fields. Many problems were brought out and

clarified. It was agreed by the panel that a QC man should be advanced in public relations and acquire a complete technical background of an operation to be most effective. This program was of benefit to our organization, as members agreed that they could use many of the ideas that were discussed.

HARRISBURG . . . "Should an inspector shut down a machine?" "Should non-standard material ever be used in production?" These timely questions were discussed during the Buzz Session at the November meeting. Although no definite answers were agreed upon, the discussion was lively and thought-provoking. The results were ably summarized by Jim Skelton, moderator for the meeting. Those serving as group leaders were: Messrs. Hoy, Lubold, Baker, Hineline, Krause, Gross, Allen, Hoffer, Ramsey, and Bailey.

Dr. Mason E. Wescott's talk on "Simplified quality controls" scheduled for the Feb. 5 meeting will attract QC and engineering personnel in the area. Dr. Wescott's name is almost synonymous with SQC and our section is honored to have him as a guest speaker. The dinner meeting will be at the YWCA.

HARTFORD . . . August B. Mundel, Sonotone Corp., spoke at the Nov. 18 meeting. His discussion of "Narrow limit gages" was very informative and offered a technique new and useful to many in the audience.

An educational course in QC is being organized for presentation to members of the Hartford Industrial Management Club beginning late in January.

The section is proud to announce that it will be host to the 15th New England Conference to be held in October of 1961.

KANKAKEE-JOLIET . . . Top management's primary function within the company is decision-making stated Gayle McElrath of the University of Minnesota at the first annual management night program. Prof. McElrath further stated that decision-making requires scientific measurements as well as the traditional methods of judgment, hunch, and educated guess. The necessary techniques for scientific measurement in decision-making are already available and tested on the practical level in the techniques of SQC. The manager, in learning these techniques, will also be learning the necessary fundamentals for making quality decisions.

Among the guests were L. S. Eichelberger, ASQC's executive secretary, and 35 Kankakee-Joliet managers. A total of 74 people attended the meeting.

KANSAS CITY, MO. . . . The 13th Midwest QC Conference was held at the Muehlbach Hotel, Nov. 6-7. Over 360 persons attended the two-day, fifteen session conference and the simultaneous training course. Highlighting the conference was a special missile reliability symposium, moderated by Dr. Lloyd Knowler of the University of Iowa and conducted by Dr. James A. Van Allen of the University of Iowa and James M. Bridges, director of electronics, Office of the Assistant Secretary of Defense.

At a special ceremony, conference chairman Dr. Frank A. Barta presented Professor Harold F. Dodge of Rutgers University with a citation in appreciation of his great contributions to the Society and the field of SQC.

LIMA—A display of *Industrial Quality Control* and reference books was one of the main attractions of the Lima section's Annual Managers Dinner held Nov. 18 at the Lima Ford Engine Plant. The dinner was held to promote better relationships with management. Shown here are (left to right) Stephen Kadar of Ford, Paul Caruso of Ford, Clair Zimmerman of Superior Tube, Martin Medows of General Electric, William Barker of General Electric, and Morris Lynn of General Electric.

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LOUISVILLE . . . The November meeting featured a preliminary education capsule. Pat Dellario presented "Sampling plans" which was a very informative review of OC and AOQ curves, the AOQL and the LTPD level of sampling plans.

The speaker for the evening was Jack Thornby of Pillsbury Mills. He presented a very interesting demonstration of "Economy in experimental design" in which the audience participated. The principle of his procedure was the use of random balance and fractional factorial. Jack presented two well written papers to each member pertaining to experimental designs.

MEMPHIS . . . The section was pleased to have a local speaker at the Oct. 20 meeting. E. P. McMahon, Nickey Brothers, Inc., presented "Harnessing extreme value theory for QC." Mr. McMahon recently completed his thesis for MA in business at the University of Tennessee on this subject.

METROPOLITAN . . . The February meeting will be of general interest with information of practical value to most QC people. It features a diverse panel to discuss QC case histories. On the panel will be Miss Mary E. Scollon of American Airlines, Alexander Sternberg of Sonotone Corp., and Nicholas Shoumatoff of West Virginia Pulp and Paper. February 19 is the date and the meeting will be held at 8 pm at the Essex House in Newark. Come out for a valuable evening. A pre-meeting clinic will be held at 7 to discuss fundamentals.

On Nov. 13 a very successful meeting was held at the Bristol-Myers' plant. The session included an interesting plant tour. (The above photo shows part of the group during one phase of the tour.) After the tour, the unusually large gathering was welcomed by "Pat" Bristol. Speakers included O. E. Johnson, vice president in charge of production, and W. C. Frey, head of the statistical services section of Bristol-Myers.

Mrs. Allegra Rogers read a paper by Dr. Ellis R. Ott who could not attend due to conflicting engagements.

MEXICO CITY . . . During the month of June, a very satisfactory SQC course was held—five of the students joined the Society.

A fall course was held during October and on Nov. 5 a special meeting and buffet was held to dismiss these students. We expect to reap a few more members as a result of this course.

Four new basic courses on QC are being prepared for this year and will probably be scheduled at three month intervals. POR EL PROGRESO DE LA INDUSTRIA EN MEXICO.

MID-HUDSON . . . Thirty-five members and guests toured the Western Printing and Lithographing Co. during the November meeting. Night superintendent Harvey Thygeson welcomed the group and gave them a brief history of the company. The tour included all phases of the printing industry—printing, binding, and packaging.

The Feb. 3 meeting will be held at 7 pm in the Poughkeepsie Inn, Poughkeepsie. Richard Hulnick of IBM, Kingston, will moderate the workshop sessions which should make this meeting one of the most interesting of the year.

MONTREAL . . . The Nov. 19 dinner meeting featured Henry J. Becker as guest speaker. His presentation "Statistical methods applied to metallurgical problems" was thoroughly enjoyed by the section's members as well as by members of ASM who joined us for this meeting.

On Nov. 24 a basic short course in SQC was started with R. Vance Ward in charge. The course is designed for production supervision and foremen and consists of 4 two-hour lectures.

Leon Bass, General Electric Co. of Cincinnati, will lead a panel at the annual management night on Feb. 11.

On Feb. 25 the section will tour the aircraft plant of Canadair, Ltd., St. Laurent.

Kingston-Brockville Sub-section . . . The third winter meeting was held Nov. 12 under the chairmanship of M. Kolsun of the RCA Victor Co., Prescott. Professor Roger Lessard of Ecole Polytechnique, Montreal, spoke on "Acceptance sampling" and demonstrated how the appropriate use of sampling can do much to promote goodwill between vendor and consumer. It provides an objective program for the acceptance of material which quite often brings the two closer together in that they become much more aware of the other's problems and can often reach a better understanding.

MUNCIE . . . November's meeting saw "awards of merit" presented to about 40 students who successfully completed the ten-week course in QC. The section is proud of this hard

clinics, conferences, and courses

JANUARY

. . . **26-30**—Three concurrent intensive courses (advanced QC and statistics, advanced motion and time study, and linear and mathematical programming), Washington University, St. Louis, Mo., contact University College, Washington University, St. Louis 5, Mo.

. . . **26—Feb. 5**—Twelfth Annual Short Course in QC by Statistical Methods, University of Illinois, Urbana, Ill., contact Prof. John A. Henry, Room 205, Mechanical Engineering Laboratory, University of Illinois, Urbana, Ill.

. . . **27-30**—15th Annual SPE Technical Conference, Hotel Commodore, New York, N. Y., sponsored by Society of Plastics Engineers, contact William C. Cleworth, Publicity Chairman, 15th Annual SPE Technical Conference, 342 Madison Ave., New York 17, N. Y.

. . . **29-30**—ASQC Metals Technical Committee Meeting.

. . . ***29-31—9th Annual Conference, Charlotte, N. C., sponsored by Textile Division of ASQC, contact L. I. Horner, Celanese Corp. of America, P.O. Box 1414, Charlotte, N. C.***

. . . **31**—Eighth Annual All-Day Conference, "E.A.S.E. of QC," Cincinnati, Ohio, sponsored by Cincinnati section of ASQC.

FEBRUARY

. . . **3**—Quality Control Management and Engineering 15-week course, University of Rhode Island, Division of University Extension, Providence, in cooperation with the Rhode Island section of ASQC, contact Alberto J. La Greca, 20 Fenwood Ave., Esmond 17, R. I.

. . . ***6-7—Middle Atlantic Conference, Traymore Hotel, Atlantic City, N. J., sponsored by ASQC, two-day conference featuring four simultaneous sessions with papers and discussions covering all phases and applications of SQC, for registration blank and detailed program write J. L. Freeman, General Motors Corp., Boxwood Rd., Wilmington, Dela.***

. . . **6-7**—Eleventh Annual Industrial Engineering Institute, conducted simultaneously on the Berkeley and Los Angeles campuses of the University of California, contact Department of Conferences, University Extension, University of California, Berkeley 4 or Los Angeles 24, Calif.

. . . **19-20**—Two-Day Conference, Durham, N. H., sponsored by the New Hampshire section of ASQC.

. . . **20**—All-Day QC Conference, University of Chattanooga, Chattanooga, Tenn., sponsored by the Chattanooga section of ASQC.

MARCH

. . . ***4-5—Pacific Northwest QC Conference, New Museum of Science & Industry, Portland, Oregon, sponsored by ASQC.***

. . . **11-12**—9th Annual Iron & Steel Conference, Pittsburgh, Pa., sponsored by the Pittsburgh section of ISA, contact R. E. Blackwell, Pittsburgh Section ISA, Box 1346, Pittsburgh 30, Pa.

. . . **20**—6th Industrial Clinic for Quality Control, Hotel Wisconsin, Milwaukee, Wis., sponsored by Milwaukee section of ASQC.

APRIL

. . . **18-22**—ASTE Annual Meeting, Schroeder Hotel, Milwaukee, Wis., sponsored by ASTE, contact Harry E. Conrad, ASTE, 10700 Puritan Ave., Detroit 38, Mich.

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IX-2.....	X-2.....	XI-2.....	XI-7.....
IX-3.....	X-3.....	XI-3.....	XI-8.....
IX-4.....	X-4.....	XI-4.....	XI-9.....
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working intelligent class. Jack S. Gantt, supervisor of quality engineering at GE's Cincinnati Jet Engine Division, addressed the graduates and members concerning the effectiveness of simple statistical techniques when properly applied. The section is grateful to Leon Bass for providing such an excellent speaker.

D. G. Browne, a vice president of the Broderick Co., has addressed many groups on "Some philosophical aspects of QC." As often happens, the speaker's home section has not been one of the groups. This will be remedied Thursday, Feb. 19, when "Browney" will address the regular 7:30 pm meeting at the Ball State Student Center. Dinner will be served at 6:30 in the Pine Shelf Room.

NEW HAMPSHIRE . . . The section is actively planning a series of QC courses in conjunction with the state university. A two-day conference will be held at Durham on Feb. 19-20 with Dr. Feigenbaum the keynote speaker. An introductory course will be scheduled in the spring with basic and advanced courses following in the next two semesters. Present plans call for providing the introductory and basic courses at Durham, Nashua, and Keene with instructors from ASQC. The advanced course will be given only at Durham with a combination of faculty members and outstanding QC men from industry. Although designed basically for all New Hampshire industry, it is anticipated that the courses will serve bordering plants in Vermont, Massachusetts, and Maine.

NEW HAVEN . . . A very interesting plant tour of the Armstrong Rubber Co. on Nov. 11 was ably conducted and plant routine described by our conductor, Joseph H. Palmieri, superintendent of QC. After the tour, Mr. Palmieri gave a short talk on QC procedure at Armstrong.

OMAHA-LINCOLN . . . The November meeting was held at the Capitol Hotel in Lincoln. Lt. Col. Bruce Pierce of the Missile and Rocket section of Redstone Arsenal at Huntsville, Ala. gave an excellent talk on the reliability program for guided missiles and showed a film of these missiles.

PARKERSBURG . . . Dr. E. Hellenbrandt of Ohio University was the speaker for our November meeting. His subject was "Mathematical analysis—management tools for decision making." Twenty-nine members and guests representing nine different companies attended this enlightening program.

PENSACOLA-MOBILE . . . The Pensacola Junior College and the section will co-sponsor a course in industrial statistics and QC during the spring semester. The course is designed for those people working directly or indirectly with QC in industrial plants.

The course material will include a brief review of frequency distribution functions in conjunction with development of control chart techniques, determination of average outgoing quality, elementary probability, significance tests, sampling inspection, and analysis of variance.

Participants will be encouraged to bring specific problems to class that are applicable to the course material being covered.

No previous statistical background will be required but will be helpful.

Lloyd R. Henry, QC engineer for the Chemstrand Corp. and a member of the section, will be the instructor. The class will meet Thursday evenings for three hours.

PHILADELPHIA . . . Members attending the meeting held Nov. 20 were treated to a very enjoyable and informative evening. Miss Besse B. Day and Dr. Francis Del Priore presented a skit entitled "The statistician and engineer can meet." The presentation was unusual, unique, humorous, and very educational. It was interesting to watch the transition of an engineer "who thought he had the complete action and interaction of the variables of an experiment accommodated for," only to find out that there was a more scientific approach than the one he was using. In the end the engineer signs up for a course in analysis of variance.

PHOENIX . . . A plant visitation of the Reynolds Metal Co. was on the agenda of the November meeting. The plant tour of this aluminum extrusion operation was preceded by a presentation which explained the plant's operation and QC procedures. The large number in attendance and the interest indicated the desire for additional plant visitations for increased understanding of QC techniques used by various companies and different types of manufacturing processes.

The first training course has been presented. The title of the course was "Basic requirements for the professional QC engineer" and was in keeping with the national theme.

PITTSBURGH . . . Over 60 members and guests attended the Nov. 25 meeting to hear Dr. Julian Toulouse give an enlightening talk on basic QC. Dr. Toulouse maintains that basic QC is not only the keeping of control charts but also the understanding of the psychological aspects of inspection. He also emphasized the effect on total costs attributed to a change in specifications or probability limits with an example from a bottle filling operation. He discussed a packaged basic training program to be given within a company. This in-company program has the advantages of containing a captive audience, ability to use confidential company data, and can be spread out over a period of time for easy absorbtion of the material and immediate application. This meeting was one of the finest the section has ever had.

PITTSFIELD . . . There was no regular meeting in November. Thus members were given an opportunity to absorb the fine technical material presented at the highly successful three-day New England Conference for which the section was host.

PORTLAND . . . The executive committee is putting the final touches to the format for the 7th annual Northwest QC Conference. The dates originally agreed as Mar. 27-28 have been changed to Apr. 4-5 to prevent conflict with another conference being held in Portland.

Dr. Worthington of Oregon State, Ray Vanderzanden of Sawyers, Don Hancock of Jantzen, and Hank Blood of Omark Industries are to be instructors for the educational part of the conference. This alone is sufficient to guarantee an interesting training session.

The section has received some new members as a result of the course conducted by Ray Vanderzanden at Portland State. Ray really did a bang-up job of teaching. The results are going to go a long way in converting northwest industry to reliance on QC and SQC. With the 7th Northwest QC Conference coming but 90 days after the completion of Ray's course, and Ray handling some of the educational periods during the conference, the section can expect some startling results from this conference in the membership increase.

RHODE ISLAND . . . Robert Schin, chief of QC at Western Electric Co., Allentown, Pa., gave a fine presentation which was replete with colorful and interesting slides. He answered the question posed by his title "Can QC pay its own way" most dramatically. It was the best talk the section has had to date.

ROCHESTER . . . The Nov. 4 meeting of the gaging and measurement sub-group was addressed by W. L. Hayes of Link Aviation Co. Mr. Hayes' topic was "Use of the Link Fringecount Micrometer in metrology laboratories."

The regular section meeting was addressed by Warren R. Purcell who did a competent and enlightening job on "Who controls quality—and how?"

On Feb. 3 the technical sub-group will meet jointly with ASA to hear J. S. Hunter of Princeton University. Mr. Hunter will discuss "Digital computer applications."

The food and beverage industries sub-group will meet Feb. 9 to hear "How QC factors affect marketing."

Rutgers University, Basic SQC Course

A basic conference series in statistical quality control will be held at Rutgers University, The State University of New Jersey, in the spring of 1959 in New Brunswick, N. J.

The 1959 series will consist of nine Wednesday afternoon and evening sessions beginning March 11 and concluding May 6.

Afternoon Sessions: 2:15-5:15. Aimed at providing a general understanding of a quality control program, including applications of control charts and the advantages and methods of scientific sampling plans. Practical applications of modern techniques will be stressed with demonstrations, group discussion, and lectures. Emphasis will be on the applications of the techniques rather than their underlying theory. Case histories of actual plant experiences will be included.

Dinner Sessions: 6:00-9:00. In cooperation with the Metropolitan Section of ASQC, nationally known leaders are scheduled to speak at the dinner meetings. They will discuss general methods and aspects of quality control.

Staff will include Professors Harold F. Dodge, Ellis R. Ott, and Mason E. Wescott.

Applications for the Conference Series should be addressed to Prof. Ellis R. Ott, Rutgers, The State University, New Brunswick, N. J.

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SECTION CALENDAR (JANUARY 25—FEBRUARY 28)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Allentown-Bethlehem	Feb. 11	Western Electric, Allentown	——	Afternoon Plant Tour	——
Baltimore	Feb. 20	Wilson's Restaurant	7:15 pm	Consumers Quality	Colston E. Warne, Consumers' Union
Battle Creek-Kalamazoo	Feb. 13	Post Clubhouse, Battle Creek	8:00	Things Vary as Things Vary	Dr. Andrew Luff, Western Michigan University
Boston	Feb. 12	M.I.T. Faculty Club, Cambridge	6:00	The Story of the Cutting Edge	C. G. Schelly, DoALL Co.
Buffalo	Feb. 10	St. Catherines, Ont.	7:00	Total Quality Control	Dr. A. V. Feigenbaum, General Electric Co.
	Feb. 23	Harrison Radiator Div., GMC, Lockport	6:30	Developing the Quality Attitude	Howard R. Botton, Harrison Radiator Div., GMC
Buzzards Bay	Feb. 12	Continental Screw Co.	8:00	Quality Control Film and Plant Tour	——
Chattanooga	Feb. 20	University of Chattanooga	——	All-Day QC Conference	——
Cincinnati	Jan. 31	Hotel Sinton	——	8th Annual All-Day Conference	——
	Feb. 18	Engr. Society Bldg.	8:00	Developing Industry Standards by Statistical Methods	D. H. W. Allan, American Iron & Steel Inst.
Cleveland	Feb. 13	Cleveland Engr. & Scientific Center	8:00	QC—Now and in the Future	C. R. Burdick, Houdaille Industries, Inc.
Columbus	Feb. 18	Kimble Glass Co.	8:00	Current Operation Research Programs	Max Astrachan, U. S. Air Force Institute
Corning-Elmira	Feb. 10	Baron Steuben Hotel, Corning	7:00	Organizing for Quality Improvement	Leonard A. Seder, Consultant
Dallas-Fort Worth	Feb. 5	Arlington State College, Arlington	8:00	The Management of Reliability Programs	Frank H. Squires, Topp Industries, Inc.
Dayton	Feb. 11	——	——	Firestone SQC	Dorsey E. Dean, Firestone Rubber Co.
Evansville-Owensboro	Feb. 17	Evansville	7:30	Narrow Limit Gaging	Edwin Schecter, Sonotone Corp.
Erie	Feb. 25	——	——	Joint Meeting with Erie Mfg. Assoc.	Dorian Shainin, Rath & Strong, Inc.
Georgia-Atlanta Group	Feb. 16	——	——	Practical Application of Basic SQC	Dr. J. J. Moder, Jr., Georgia Institute of Technology
Greater Detroit	Jan. 31	——	——	7th Annual Dinner Dance	——
Greater Muskegon	Feb. 12	Bill Stern's Steak House	6:30	Ladies' Night	Herbert Jones, Western Michigan University
Hamilton	Feb. 10	St. Catharines	8:00	Joint Meeting with St. Catharines section	Dr. A. V. Feigenbaum, General Electric Co.
Hamilton-Middletown	Feb. 11	Bendix Plant	7:15	Plant Tour	K. L. Mikelson
Harrisburg	Feb. 5	YWCA	6:30	Simplified Quality Controls	Dr. Mason E. Wescott, Rutgers University
Hartford	Feb. 17	Club Alden	6:30	Estimating the Precision of Measuring Instruments and Product Reliability	Frank E. Grubbs, Aberdeen Proving Grounds
Kankakee-Joliet	Feb. 2	Tony's Restaurant, Joliet	6:30	Corrective Action: What & How	Edward Clark, General Motors Corp.
Kansas City, Mo.	Feb. 19	Blue Hills Steak House	6:00	QC as Related to Management and Employees	Simon Collier, Johns Manville Corp.
Los Angeles	Feb. 11	Rodger Young Auditorium	6:00	Weapon System, Concept and QC	Robert H. Anderson, North American Aviation, Inc.
Memphis	Feb. 5	Memphis State University	8:00	Latest Department of Defense Concepts and Procedures on Inspection	Wayne Bradley, St. Louis District Corps of Engineers
Metropolitan	Feb. 19	Hotel Essex House, Newark	7:00	Panel on QC Case Histories	Mary E. Scollon, Alexander Sternberg, Nicholas Shoumatoff
Mid-Hudson	Feb. 3	Poughkeepsie Inn, Poughkeepsie	7:00	Workshop	Richard Hulnick, IBM Corp.
Montreal	Feb. 11	Windsor Station	6:30	Management Night	Leon Bass, General Electric Co.
	Feb. 25	Canadair, Ltd., St. Laurent	——	Plant Tour	——
Muncie	Feb. 19	Student Center	7:30	Some Philosophical Aspects of QC	D. G. Browne, Broderick Co.
New Hampshire	Feb. 19-20	Durham	——	Two-day QC Conference	——
Pensacola-Mobile	Feb. 17	Brookley AFB, Mobile	7:00	Air Force QC Plans	James C. Sorenson, Aeronca Aircraft Corp.
Philadelphia	Feb. 19	Germantown Cricket Club	6:30	Statistical Methods in Engineering Design	Enoch B. Ferrell, Bell Telephone Laboratories
Phoenix	Feb. 12	Westward Ho Hotel	6:30	Administration of QC by U. S. Navy	Frank Burns, Director of Inspection of Naval Materials
Pittsburgh	Jan. 27	YWCA, Wood St.	6:30	QC in the Manufacture of Refractories	W. D. Fitzpatrick, Harbison-Walker Refractory Co.
	Feb. 24	YWCA, Wood St.	6:30	QC in Metal Can Manufacture	John De Canio, Continental Can Co.
Pittsfield	Feb. 11	Stanley Club	8:00	QC Problems in Automated Assembly	W. C. Stone, IBM Corp.
Portland	Feb. 3	Owens-Illinois Glass Co.	7:30	QC in Glass Making	William P. Trowbridge, Owens-Illinois Glass Co.
Rhode Island	Feb. 19	Providence Engr. Society Bldg.	8:00	GE Vendor Certification Program	Chester Gadzinski, General Electric Co.
Rochester	Feb. 3	Chamber of Commerce	6:15	——	Robert Morris
	Feb. 9	Chamber of Commerce	6:15	How QC Factors Affect Marketing	——
	Feb. 17	Chamber of Commerce	6:15	U. N. Project—SQC in India	Ellis R. Ott, Rutgers University
St. Charles	Feb. 17	Club Arcada	6:30	Case Studies in Successful Applications of SQC	Prof. H. R. Swenson, Illinois Institute of Technology
St. Louis	Feb. 18	——	8:30	Annual Party	——
Salt Lake City	Feb. 12	Union Bldg., University of Utah	7:30	QC Testing and Analyzing Performance of the Ram-jet Engines	J. W. Stephenson, Marquardt Aircraft Co.
San Antonio	Feb. 10	Hilton Hotel	7:30	Management of Reliability Programs	Frank H. Squires, Topp Industries, Inc.
San Diego	Feb. 9	Lafayette Hotel	7:30	Defense Department Reliability	Dr. Leslie W. Ball, Reliability Consultant
Scranton-Wilkes-Barre	Feb. 10	Harris Restaurant, W. Pittston	6:30	Western Electric QC System	Robert Schin, Western Electric Co.
State Univ. of Iowa	Mar. 5-6	Midwest Mfg. Corp., Galesburg, Ill.	9:00 am	Two-Day Meeting	——
Syracuse	Jan. 27	Syracuse Turners	8:00 pm	Modern Use of the Range	R. S. Bingham, Jr., Carborundum Co.
Toledo	Feb. 12	Libbey Plant, Owens-Illinois Glass Co.	6:30	Plant Tour	——
Toronto	Feb. 11	University of Toronto	8:00	Frequency Distribution Analysis	Ervin F. Taylor, The Martin Co.
	Feb. 25	Sign of the Steer	6:30	Non-Destructive Tests and Gamma Radiography	C. F. Thompson, Nuclear Systems Div., Budd Corp.
Univ. of W. Ontario	Feb. 11	Gair Box Co., London	8:00	Plant Tour	——
Youngstown	Feb. 5	Astoria Cafe, Warren	8:00	Significance Tests and the Dollar Sign	Dr. Fred C. Leone, Case Institute of Technology

On Feb. 17 the regular section meeting will be addressed by none other than Dr. Ellis R. Ott, Rutgers University. Dr. Ott will tell us about "U. N. project—SQC in India."

It is not too soon to remember that the section's 15th Annual Clinic will be held Mar. 26 on the University of Rochester campus.

ST. CHARLES . . . Dr. Leonard W. Swanson, Arthur Anderson & Co., addressed the Nov. 18 dinner meeting on the subject "Some applications of operations research." A pre-dinner seminar on "sampling" was conducted by Prof. H. R. Swenson, Illinois Institute of Technology.

The Feb. 17 meeting will be held at the Club Arcada. Prof. H. R. Swenson will speak on the subject "Case studies in successful applications of SQC." Registration and social hour will be held at 5:30 pm followed by dinner at 6:30. For reservations contact Harry E. Jahns, Burgess-Norton Mfg. Co., Geneva, Ill.

ST. LOUIS . . . The November meeting was held at the Golden Fried Chicken Loaf Restaurant. The speaker for the evening was Carl E. Noble of Kimberly-Clark Corp., Neenah, Wis. His topic was "Administrative applications of QC."

The annual party will be held on Feb. 18 at 8:30 pm.

SALT LAKE CITY . . . The Nov. 20 meeting gave the audience an insight into the basic concepts, organization, and operation of the quality program of the Ordnance Department. The subject was entitled "Ordnance quality assurance" and was treated by B. E. Wessel, Sperry Utah Engineering Laboratory.

The educational lecture which preceded the main talk was given by H. W. Schultz, Hill AFB, on the subject "Continuation of the laws of chance summarized by Sterlings formula." This was the third lecture in the educational program undertaken this year.

We missed the presence of chairman Cecil McCarty. Cecil was ready to attend the meeting when a very high temperature landed him in the hospital instead. He was confined to the hospital for several days for observation and testing. We hope for speedy recovery.

Newell Crookston, last year's secretary, makes a round-trip of over 70 miles to attend the section's meetings. His attendance to date is 100 percent.

SAN ANTONIO . . . The section held its third meeting on Nov. 11 at the Hilton Hotel. Dorian Shainin, Rath & Strong, Inc., presented "How managements have drastically reduced operating costs." Mr. Shainin's presentation was most interesting and was centered around the idea of finding the causes for producing discrepant items during production. Through the use of this new concept in management, substantial savings have been realized by many manufacturing concerns. Our section would like to recommend to other sections that have not had the opportunity of hearing Mr. Shainin that it would be to their advantage to schedule him for a visit when possible. Since some of our local managers and members were unable to be present for this meeting, the entire program was tape-recorded and will be available for future use.

Our education chairman reported that final arrangements are being made to have a QC course available by Feb. 1.

SAN DIEGO . . . Members and guests will have an opportunity to find out what takes place in the council chambers when management calls in a "consultant." Dr. Leslie W. Ball, Magill University alumnus and reliability consultant, will address the Feb. 9 meeting on the theme "Defense Department reliability specification requirements—what they mean to industry."

SAN FRANCISCO BAY AREA . . . John A. Connor of Hughes Aircraft Co. gave a most interesting and informative talk at our dinner meeting on Nov. 10. The lecture and dinner was enjoyed by 68 members and guests. In his talk entitled "Catastrophic failures—the residue of electronic design," Mr. Connor discussed the underlying basis for isolating catastrophic failures and the establishment of design success indices based upon the statistical characteristics of these occurrences.

The executive committee held a meeting on Nov. 24. The agenda, in part, covered: nomination for 1958 Shewhart Medal Award; nomination from District 17 (effective July 1) for director to ASQC Board of Directors; and nomination from District 17 for district representative.

SCRANTON-WILKES-BARRE . . . A. L. Lambert, charter section member, was originally scheduled to speak at the last meeting but was unable to appear. Robert Zingerman was able to arrange a tour of Eureka Specialty Printing plant in Scranton. The guides for the tour also served on a panel dur-

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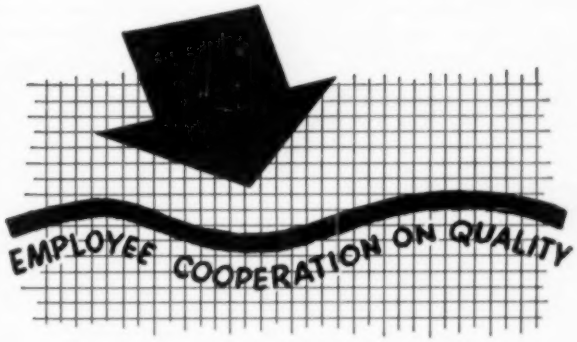

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The University of Scranton is hoping to offer an evening course in industrial statistics and QC in cooperation with the section with a minimum of 15 students. The course would begin Jan. 26.

The meetings this year are being held at Harris Restaurant in West Pittston. The pleasant surroundings and midway location make this meeting place a happy compromise for members and guests from both areas.

SOUTH TEXAS . . . Nov. 12 was the date of a most thought provoking talk on "How managements have drastically reduced operating costs." Dorain Shainin, Rath & Strong, Inc., was the guest speaker.

STATE UNIVERSITY OF IOWA . . . The next two-day session will be held Mar. 5-6 at the Midwest Manufacturing Corp., Galesburg, Ill. Registration begins at 9 am. Andrew Burrise, director of QC, and Jesse H. Baker, chief inspector, will present "SQC at Midwest Manufacturing Corp." at the Thursday afternoon session. On Friday, Dr. Cecil C. Craig, University of Michigan, will direct the technical session.

SYRACUSE . . . Our section president and several other members attended the November meeting of the Utica section and made tentative plans for a one-day conference.

Instead of scheduling a regular meeting for February, the section is planning on participating in the engineering symposium to be offered by the Technical Societies Council as part of "engineering week." Remember the date—Saturday, Feb. 28—and plan to attend.

TOLEDO . . . W. E. Barker and M. R. Lynn, Jet Engine Department, General Electric Co., were speakers at the section's November "management night" meeting. Mr. Barker, QC division, illustrated the application of statistical techniques while Mr. Lynn, production superintendent, pointed out the savings secured.

TORONTO . . . A change of plans for our dinner meeting on Nov. 12 resulted in the appearance of Larry Sellick as speaker of the evening replacing W/C G. B. Waterman who was unable to attend.

The talk given by Mr. Sellick, based on RCAF QC and reliability requirements, dealt in considerable detail with applications to component parts, assemblies, and complete aircraft. The address was followed by a lively and most interesting discussion period.

UNIVERSITY OF WESTERN ONTARIO . . . A very successful QC forum was held jointly with the Hamilton section on Nov. 13. The speakers were: C. A. Bicking, Carborundum Co.; P. B. Proctor, Johns Manville Corp.; Paul S. Olmstead, Bell Telephone Laboratories; and B. H. Lloyd, Price, Waterhouse & Co.

On Nov. 19 Dr. W. H. Bexton, Waterloo College, spoke at the meeting which was held at Waterloo College. The subject of Dr. Bexton's talk was "Human relations in QC." Many of the everyday problems which we face in practicing QC were discussed. Following the meeting, coffee and doughnuts were served in the Torque Room.

A plant tour of the Gair Box Co. plant at London will be held on Feb. 11 at 8 pm. The tour will be followed by a movie supplied by the National Safe Transit Committee entitled "Shipping tests."

UTICA . . . On Nov. 6 the section held its meeting at the City Club. Dr. Robert Lusser, Redstone Arsenal, spoke on the use of safety margins in designing for reliability. His talk was well presented and the interest of the group was heightened by slides, a movie, and a demonstration of Dr. Lusser's reliability demonstrator. This demonstrator dramatically portrays the multiplication law of overall missile reliability. By pretending that each trial of the demonstrator represented a missile launched, the effect of a 36.5 percent probability of success was impressed on the audience. All came to realize that this does not mean that 1 out of 3 launchings would be a success, but often eight launchings in a row could be failures.

A pleasant surprise developed when a pitcher which most members and guests assumed contained water turned out to be filled with martinis.

All of which proves that no one should miss a meeting.

YOUNGSTOWN . . . Another popular dinner meeting has been planned for Feb. 5. Members and guests will meet at 6:30 pm at the Astoria Cafe in Warren. Following the dinner, Dr. Fred C. Leone of Case Institute of Technology will speak on "Significance tests and the dollar sign."

SIGNIFICANT DIFFERENCES

. . . Boston—Recent position changes among section members are: W. S. Hertzmark, supervisor-quality control, Raytheon Mfg. Co.; Guy S. Holbrook, Jr., plant manager, Houghton Mifflin Co.; Burton G. Howarth, magnetron prod. manager, Raytheon Mfg. Co.; Herbert H. Hoyle, QC manager, Raytheon Mfg. Co.; Bernard J. Jagiello, sheet metal model maker, Raytheon Mfg. Co.; Richard E. Jones, QC manager, Sanborn Co.; and Miss D. H. King, technical specialist, Polaroid Corp.

. . . Baltimore—Ervin F. Taylor, The Martin Co., was promoted to supervisor, quality engineering.

. . . Chicago—James B. Paschal has been appointed manager of quality control of the Alemite and Instrument Division of Stewart-Warner Corp.

. . . Cincinnati—Leon Bass, past president of ASQC, acted as conference leader on the subject "Cost reduction through improved QC" at a recent conference sponsored by the

Youngstown Section Holds "Top Management" Night

The November meeting of the Youngstown Section of the American Society for Quality Control proved to be even better than anticipated. An excellent speaker, a well planned program, and a chance to entertain the boss made this "Top Management Night" one of the best in recent years. The sixty-five members and guests also enjoyed a fine steak dinner and several hours of informal fellowship.

Warren R. Purcell of Raytheon Manufacturing Company, Lowell, Massachusetts spoke on "Who Controls Quality—and How?" He suggested that general management, research and development, design, and sales are just as responsible for quality as production and inspection. Mr. Purcell enumerated the methods by which each department can contribute to product quality. He pointed out that control of quality is not exclusively the domain of quality control engineers. Mr. Purcell, whose talk was liberally sprinkled with humorous examples, emphasized this in his conclusion by saying "Everybody Controls Quality—And How!"

Top Management Night brought out many members, their bosses and friends, as well as other guests from management. Ron White and Bob Baxter started the festivities by presenting a frequency distribution chart showing a comparison of shoe sizes between the "bosses" and their "understudies." Since both groups had nearly the same size distribution it was concluded that the "understudies" have a chance to succeed. Mr. Purcell, who was introduced by Paul Belter of the Program Committee, commented that all present were on "firm footing". Following the formal program Chairman Bob Jones invited those present to remain and continue the discussion informally.

There was a splendid representation from industries in Youngstown, Warren, and many surrounding Ohio and Pennsylvania communities. The attendance list includes representatives of top management, research, sales, and production as well as inspection and quality control. This demonstrates the great interest in the speaker and his subject. Many present expressed the desire to become affiliated with ASQC. Without a doubt this was an outstanding meeting.

Guest speaker Warren R. Purcell of Raytheon Manufacturing Co. and officers of the Youngstown section are shown just before the dinner. Left to right, they are: Paul Belter, vice chairman; Bob Jones, chairman; Mr. Purcell; Bill Cain, treasurer; and Fred Eboch, publicity.

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(45) Proceedings of the All-Day Conference on Quality Control, September 7, 1957 14 papers (bound volume)	2.00
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(76) ASTM Manual on Quality Control of Materials	2.50
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(80) NSMPA Manual on Quality Control Sampling Volume II, "Highway Markers to Better Quality"	1.25
(81) NSMPA Manual on Sampling Inspection Volume III, "Do It Yourself Sampling Inspection Installation"	1.25
NSMPA Manuals, Vols. I-III when purchased at same time	***3.50***
(83) Charles R. Hicks, "Fundamentals of Analysis of Variance," Reprint from IQC Vol. XIII, Nos. 2, 3, 4, August, September, October, 1956	.50
(84) Case Histories on Statistical Methods for Quality Control, by Metals Technical Committee (bound volume)	1.00
(85) Morris James Slonim, "Sampling in a Nutshell"	1.00
(86) Warren R. Purcell, "Who Controls Quality—and How?" Reprint from IQC Vol. XV, No. 4, October, 1958	.10

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Society for the Advancement of Management which was held at Xavier University.

. . . Cleveland—Congratulations are due Steve Bates and John Occassione who rise before the sun to regularly attend each session of the Continental Classroom course in Advanced Physics.

. . . Corning-Elmira—Joseph M. Sheehe was recently appointed supervisor of QC of the cathode ray department of the Westinghouse Electronic Tube Division. Mr. Sheehe previously was an applications engineer of the same department.

. . . Cumberland—J. S. Sirockman, Jr., Celanese Corporation of America, has accepted a position as extrusion and textile manufacturing superintendent at the Edmonton plant of Canadian Chemical Co., Ltd.

. . . Georgia—Ivan L. Lester is now technical director of the Mead-Atlanta Paper Co. He was formerly works manager of Georgia Kaolin Co., Dry Branch.

William G. Gage, formerly of California, is now in charge of quality control at Scientific-Atlanta, Inc.

Edward W. Drake, formerly QC engineer with International Latex Corp., LaGrange, is now with Mead-Atlanta Paper Co.

. . . Hamilton-Middletown—Ray Dick, formerly chief of packaging materials-QC for the Pillsbury Co., has been promoted to packaging materials engineer. His job will be acting as liaison to production in solving packaging problems. His headquarters will be Minneapolis servicing the various plants.

. . . Harrisburg—Herman Singer has joined the QC force at American Chain and Cable Co.

Al Krause has been selected as section vice chairman to succeed Mark Ryder who resigned from that position.

Richard Smeloff has transferred his membership to the Harrisburg section. Welcome, Dick!

R. Fred Granzow has been appointed to the position of supervisor of liaison engineering department, Amp, Inc.

. . . Hartford—After serving faithfully for seven years, Bob Selig has resigned as representative to the New England Conference Council. Al Aubin has been appointed his successor.

Alfred E. Nelson has transferred from Underwood to the Hayden Electric Co. in Torrington as chief inspector.

Charlie Kropp, formerly with Hamilton Standard, is now associated with Wilco Tool & Machine Co., Bolton.

. . . Kansas City, Mo.—Congratulations to Bill Jeffries, QC manager at Hallmark Cards, Inc., who will soon assume new duties as assistant to the vice president in charge of production.

. . . Los Angeles—Lester P. Gideon, formerly senior quality engineer at Firestone Guided Missile Div., has transferred to Hughes Aircraft Co. as quality director staff engineer.

. . . Memphis—The section has sponsored two night courses in statistics and QC at the University of Tennessee branch at Memphis. E. P. McMahon taught a course in statistics and Dr. A. F. Johnson instructed a course on experimental design.

. . . Mid-Hudson—Dwight Bellinger, section membership chairman, has announced the beginning of a membership drive. The contest, running from November through February, is to encourage the growth of the section. A free testimonial dinner will be awarded the two members bringing in the most new members during the period.

. . . Phoenix—J. G. Solauf, manager of QC of the General Electric computer department, has been elected section chairman to fill the vacancy left by R. T. Lorren.

. . . Pittsburgh—D. C. McCune has been promoted to senior staff statistician at Jones and Laughlin Steel Corp.

John Hromi gave a talk on evolutionary operations at the Churchill Valley Country Club as part of a "Science Teachers Day" program of the Allegeheny valley.

. . . Pittsfield—There was an exceptionally large amount of favorable comment concerning the exhibits displayed in the lobby of the Wendell-Sherwood Hotel during the recent 12th New England QC Conference held here.

What many did not know was that Joseph La Mountain, section secretary, was the talented artist who hand-painted illustrations of the various stages in the process of fine papermaking, which was the theme of the highly effective Byron-Weston Co. exhibit.

. . . St. Charles—John P. James, section vice chairman, was promoted to manager-production for the Flexonics Corp. and transferred to Santa Ana, Calif. Ralph Von Osinski, Chicago Rawhide Mfg. Co., Elgin, has taken over Mr. James' duties as vice chairman of the section.

. . . St. Louis—Since Nov. 1, 1958, W. H. von Meyer has been associated with T. Hamm's Brewery, St. Paul, Minn. Mr. van Meyer is a past chairman of the section and at present is chairman of ASQC's Brewing Technical Committee. The section wishes him the best of luck in his new venture.

. . . Salt Lake City—Eugene Stone, past section treasurer, obtained a Master's Degree in Business this year from the University of Utah. His thesis was of unusual interest to the local membership because it consisted of a survey of industrial QC practices in Utah.

. . . Scranton-Wilkes-Barre—Charles Rubin, past chairman of Binghamton section, has accepted the position of QC manager at the W. L. Maxson plant in Old Forge. The section welcomes Mr. Rubin to this area and congratulates him on his new position.

. . . Syracuse—William H. Armstrong has accepted a new position with Copeland Refrigeration Co., Sidney, Ohio. He has transferred his membership to the Dayton section.

. . . Toledo—Ward Wright, section vice chairman, is recovering from a recent gastrectomy. His many friends wish his speedy return to our fold.

. . . Utica—V. A. Melfi has been appointed superintendent of General Electric's sidewinder QC sub-section.

Wiliam Miller has accepted the position of QC engineer with Texas Instruments, Dallas, Texas.

ASQC Announces

Advancement and New Members

(as of October 31, 1958)

CLARKSON, MAX W., Detroit, Mich.
CLEMENT, BAXTER C., Lexington, Ky.
CLOSE, COURTNEY T., Scranton, Pa.
COOK, HARDY M., JR., Baltimore, Md.
CORIATY, JOSEPH S., Wyandotte, Mich.
CORNELL, HENRY L., Kenmore, N. Y.
CORRELL, ROBERT P., Macungie, Pa.
COURTNEY, RICHARD T., Indianapolis, Ind.
CRAIG, KENNETH W., Albuquerque, N. M.
CROW, RICHARD A., Waco, Tex.
CUMMINGS, CLAUDE H., Tulsa, Okla.
DAVEY, ARTHUR B., JR., West Townsend, Mass.
DAVIDSON, ANDREW M., Fairfield, Conn.
DAVIS, DEE R., San Bernardino, Cal.
DE SERIO, DONALD A., Rochester, N. Y.
DE VORE, ROBERT W., Albuquerque, N. M.
DEAN, HASWELL M., Blountville, Tenn.
DEAN, ROBERT W., Albuquerque, N. M.
DEL PLAINE, WERTER A., San Diego, Cal.
DEROSE, THOMAS E., Poughkeepsie, N. Y.
DICKEY, CHARLES E., Ft. Worth, Tex.
DILLINGHAM, FLOYD L., Orlando, Fla.
DONALDSON, JOHN, Fairport, N. Y.
DRAKE, DONALD M., Oakmont, Pa.
DREW, CARL E., Albuquerque, N. M.
DULEMBA, HENRY S., Haverhill, Mass.
DUNKER, WILBUR A., Towson, Md.
DURKIN, THOMAS M., Cleveland, Ohio
DYE, DONALD L., Swarthmore, Pa.
EFRAM, RUDOLPH H., Detroit, Mich.
EGGE, EDWIN G., Riverside, R. I.
ELLIOTT, CHARLES W., Tecumseh, Mich.
ELLIS, WILLIAM B., JR., Milwaukee, Wis.
FARRELL, JAMES L., Rockford, Ill.
FENTON, JOHN D., Ft. Worth, Tex.
FITZGERALD, EDWARD G., Rochester, N. Y.
FLEMMING, WILLIAM D., Bristol, Tenn.
FLOWERS, GALEN F., Whittier, Cal.
FORD, JARVIS W., Dallas, Tex.
FRANKLIN, JOHN W., Tulsa, Okla.
FRANKLIN, MAURICE G., Chattanooga, Tenn.
FRY, WILLIAM A., JR., Poughkeepsie, N. Y.
GALLIMORE, CARLOS E., Galax, Va.
GANGROSS, CARL, Pittsfield, Mass.
GANNON, RICHARD E., Tulsa, Okla.
GARDA, DOMINIC J., W. Leechburg, Pa.
GAULT, CHARLES E., Albuquerque, N. M.
GETTY, ROBERT L., Worthington, Ohio
GICHTIN, ABRAHAM L., Los Angeles, Cal.
GINSBURG, HERBERT, E. McKeesport, Pa.
GOMEZ, MIKE, Blountville, Tenn.
GOSS, JOHN E., Minneapolis, Minn.
GRANDFIELD, ALLEN L., Arlington, Tex.
GREENBAUM, SIDNEY, Lawrence, Mass.
GREENBERG, HAROLD P., Saxonville, Mass.
GREENBERG, PAUL, Westfield, N. J.
GROSS, JOHN M., Greeneville, Tenn.
GROTT, JOSEPH C., Columbus, Ind.
HADDEN, JOHN A., Rexdale, Ont., Canada
HAGOOD, RALPH O., Orlando, Fla.
HALLER, JAMES G., Erie, Pa.
HALSEY, GEORGE H., Akron, Ohio
HAMM, HOWARD W., Pittsfield, Mass.
HAMMOND, JAMES A., Milwaukee, Wis.
HAMMOND, RICHARD, Irving, Tex.
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HANCOCK, DALLAS T., Dallas, Tex.
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HARVEY, EUGENE C., JR., Orlando, Fla.
HEATHCOTE, DONALD C., Dallas, Tex.
HECKEL, CHARLES F., Cincinnati, Ohio
HEIM, CLARENCE W., Cincinnati, Ohio
HENSLEY, JOHN D., Mobile, Ala.
HERRICK, MALCOLM P., Pittsford, N. Y.

Hobbins, Alfred J., St. Paul, Minn.
Hogg, Willard D., Atglen, Pa.
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Holley, Philip W., Waco, Tex.
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Hoover, Kenneth E., Poughkeepsie, N. Y.
Horasan, Hachy, Detroit, Mich.
Hoverter, Bryce E., Jr., Reading, Pa.
Howard, Thomas C., Dallas, Tex.
Huskey, Bobby W., Plano, Tex.
Irwin, Maurice D., De Witt, N. Y.
Janke, Harold E., Lincoln, Nebr.
Jennings, Frederick A., Jr., Richmond, Va.
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Johnson, Edwin H., Waco, Tex.
Johnson, Eugene A., Minneapolis, Minn.
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Jones, William C., Arlington, Tex.
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Jordan, Jerome M., Dallas, Tex.
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Klein, Jerome, Philadelphia, Pa.
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Browne, Clifford L., Chenango Forks, N. Y.
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Toth, August J. Rochester, N. Y.
Vinson, Thomas N., Baltimore, Md.
Wilke, Howard R., Sepulveda, Cal.
Wylie, Aubrey E., East Lansing, Mich.

(as of November 24, 1958)

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Cheever, John F., Watertown, Mass.
Clark, Shirley M., Montreal, Que., Canada
Costello, Joseph S., Hummelstown, Pa.
Dana, Richard L., Canton, Ohio
Dressler, Wilton F., Montreal, Que., Canada
Friedlander, Forrest B., Veinna, W. Va.
Fockler, Donald D., Lima, Ohio
Gattuielli, Carlo J., Medford, Mass.
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Harris, Jennings, St. Louis, Mo.
Heller, Randall L., St. Louis, Mo.
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Barr, Oliver F., Liverpool, N. Y.
Bauman, William W., North Canton, Ohio
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Bedunnah, Robert E., Cincinnati, Ohio
Berghofer, Arnold A., Phoenix, Ariz.
Bergum, Alvin L., Montovia, Calif.
Bitting, Robert J., Goshen, Ind.
Blake, Harry J., Phoenix, Ariz.
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Brown, Dennis A., Georgetown, Ont., Canada
Brown, Loyal W., Wellington, Kans.
Budd, William J., Warren, Mich.
Bunnell, Charles D., Buena Park, Calif.
Burkart, Victor H., Orlando, Fla.
Burnett, Thomas L., Endicott, N. Y.
Butkiewicz, Eugene, Fraser, Mich.
Callihan, John W., Newark, Del.
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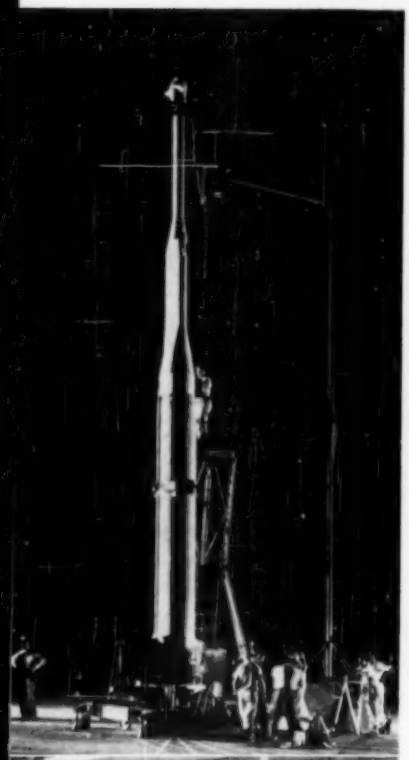

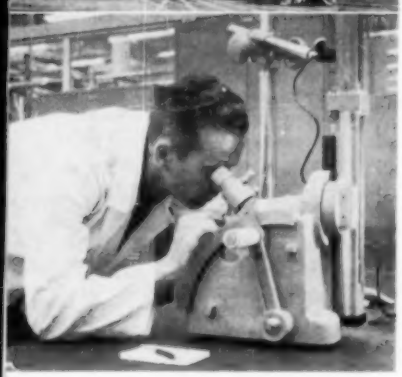

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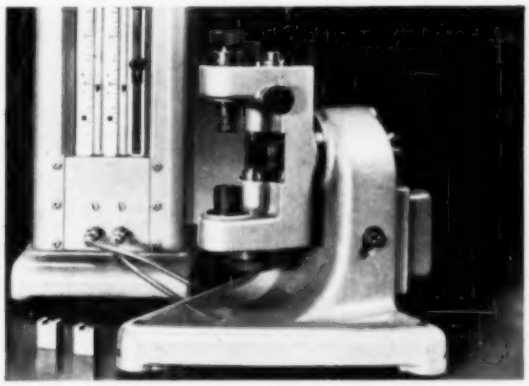

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